MANUAL TRAINING

J. M. TATE

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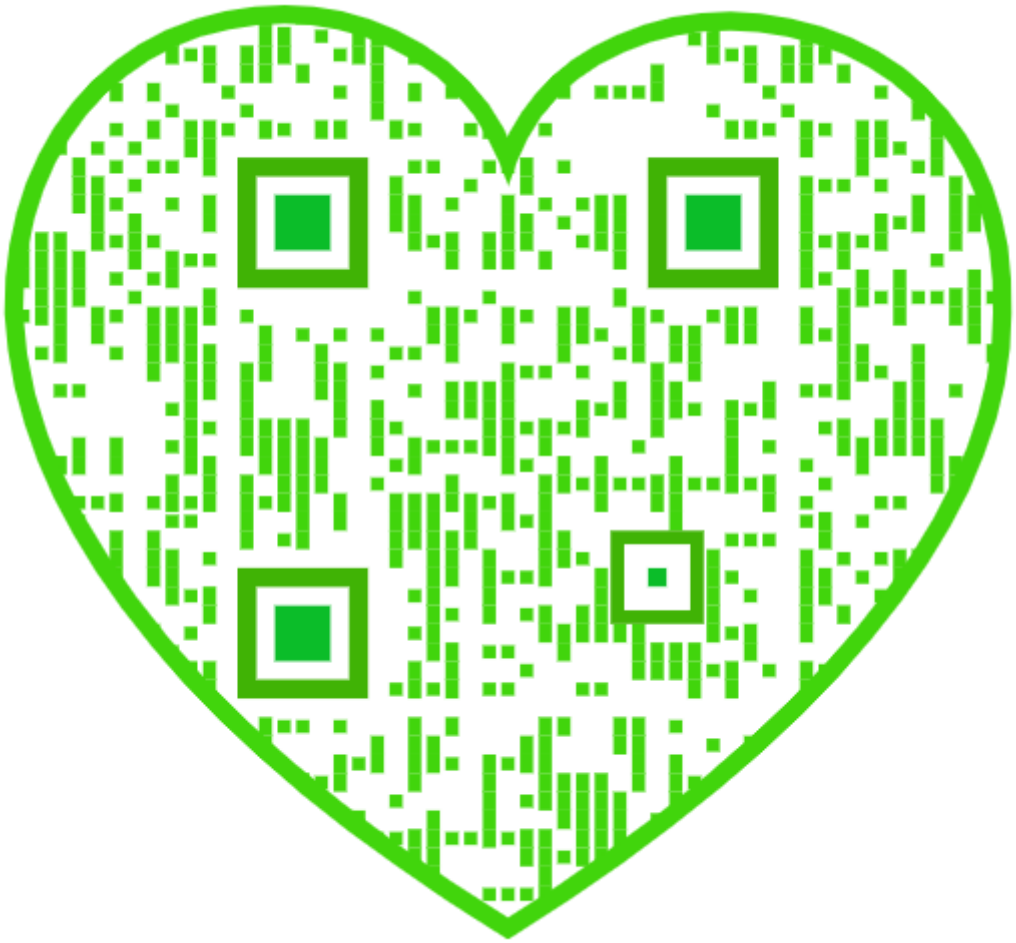

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TRAINING

IN

WOOD-WORK

DESIGNED FOR USE IN
MANUAL TRAINING AND TECHNICAL SCHOOLS

CONSISTING OF THREE PARTS

CARPENTRY, WOOD-TURNING AND PATTERN WORK

BY

JAMES M. TATE

INSTRUCTOR IN CARPENTRY, WOOD-TURNING, WOOD-CARVING
PATTERN AND FOUNDRY PRACTISE

COLLEGE OF ENGINEERING
AND THE MECHANIC ARTS
UNIVERSITY OF MINNESOTA

FIRST EDITION

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PREFACE.

The character and object of this book is set forth on its title page. It is a manual designed principally for the assistance of students in wood-work in its various branches as well as a help to the instructor. The author has endeavored to present the subject in such a manner as to make simple the transition from the easier to the more difficult operations. The exercises have been selected after an experience in this line of instruction, covering a period of twelve years and will be found practical in their application to students in manual training in technical and industrial schools. Part first, Carpentry, is intended to cover from sixty to seventy hours of work. Part second, Wood-Turning, not to exceed thirty-five hours. Part third, Pattern-Making, fifty or sixty hours, thus making a course which will be found to touch the principal points in the three branches of wood-work commonly taught in manual training schools or schools of technology or engineering. It has been the aim of the author to give in this course just enough instruction to enable the student to study the problems for himself, thereby the better fitting him for the construction of patterns for any machine which may be assigned him to complete his course in pattern-making, which is changed annually. A perusal of this work will disclose many features which the author feels sure will commend themselves to instructors and others interested in this department of school work. With the hope that these pages may prove a valuable aid to students and teachers alike, this work is presented to the public.

James M. Tate.

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FIRST PART.

The Care and Use of Tools.

It is conceded by all practical mechanics that no workman can do good work without first being able to put tools in proper condition.

The tools supplied to each student and which he is required to keep in order, are as follows:

1 Jointer plane.	1 Try square.
1 Jack plane.	1 Bevel square.
1 Block plane.	1 Hammer.
4 Paring chisels.	1 Screw-driver.
1 Marking gauge.	1 Back saw.

These tools are to be kept at each desk, and under the care of the student assigned to such desk, who will be held responsible for them and their condition. There are numerous other general tools for use in the shop, which may be obtained in the tool room when the work assigned to the student may require their use.

The first operation to be understood by the student, is the grinding of a chisel or a plane bit. To do this properly requires great care. The tool should be held upon the grindstone at an angle of about 22 degrees for soft pine, or about 30 degrees for hard wood. It is advisable to hold the tool on the grindstone in such a position that the grinding will be in a direction toward the cutting edge of the tool, as shown in

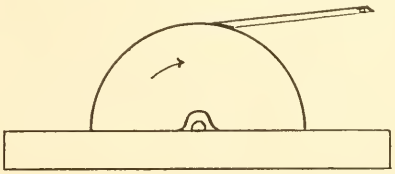

Fig. 1.

Fig. 1., to prevent a feather or wire edge. The tool while being held on the grindstone should be moved slowly, back and forth, at right angles to the motion of the stone, to prevent grooves or uneven places being made on the tool edge. When the grinding is completed, the tool should appear as shown in Fig. 2 and not as in Fig. 3, which is in poor condi-

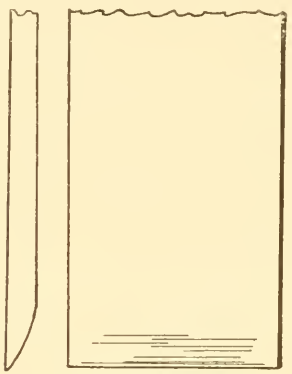

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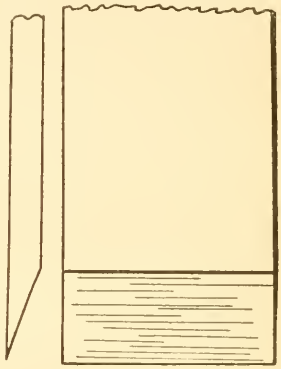
Fig. 3.



CORRECT

Fig. 2.

tion. The method is applicable to plane irons and chisels when the grinding is done free-hand, but various devices may be used to do the work of grinding in a much more accurate way. One very successful device is shown in Fig. 4, where-

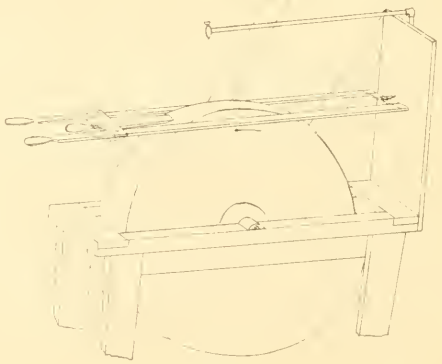


Fig. 4.

by the tool may be held in a fixed position, and a true bevel may be ground on the tool without the operator necessarily being a skilled workman. Much more might be said on this subject, but with these few suggestions a beginner may become proficient with but little practice. After being properly ground the tool should be whet upon an oilstone to insure a smooth cutting edge, but in no case should a tool be ground or whet on the flat side. The proper angle at which the tool should be held on the oilstone will be better understood by a glance at Fig. 5.

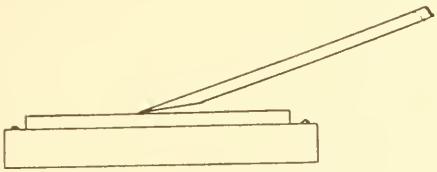


Fig. 5.

To remove wire or feather edge, which may be caused by too much grinding or whetting, a leather strap should be used, after which the tool will have a fine and smooth cutting edge, providing the operation has been properly performed.

The gouge is a chisel curved or concaved so as to form a curved cutting edge. Gouges are ground on both inside and outside, as the work may require. Inside ground gouges, should be ground on the round edge of an emery wheel, but great care must be taken not to draw the temper by too fast grinding or too great pressure. The outside ground gouge may be ground on a common grindstone, but the tool must be rocked from side to side in order to bring the convex surface in contact with the grindstone.

Whetting a gouge may be best accomplished with the round edge of a slipstone, after which the use of a leather strap adds much to the smoothness of the edge and its cutting qualities.

The rules laid down in the foregoing pages will apply to edge tools in general. After a tool has been used for some

time, and has had the operation of whetting performed on it a number of times after grinding, it is necessary to repeat the grinding.

The proper manner in which to use a plane will next be considered. The jack plane is made use of to take off the rough outside surface, and the jointer, to true up and smooth the surface, thus producing a true plane. The jack plane iron should be ground somewhat rounding, so as to appear below the bottom of the plane, as shown in Fig. 6. This is

Fig. 6.

the proper tool to use in removing a surplus of stock. The edge of cutter being curved, causes it to cut more easily, and the work may be done more expeditiously and easily for the operator. The jointer iron should be nearly straight across and only cut a very thin chip. See Fig. 7. The block plane

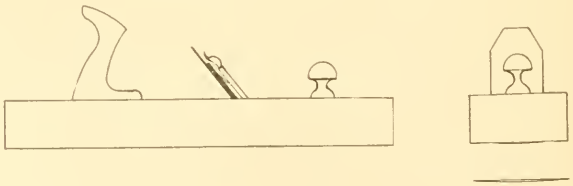


Fig. 7.

should be ground and whet in much the same manner as the jointer, but the cutting iron is placed in the plane in an inverted position, as compared with the jointer or jack plane.

See Fig. 8. This is due to the fact that the iron is set at a less angle than in the jack or jointer planes. The block plane

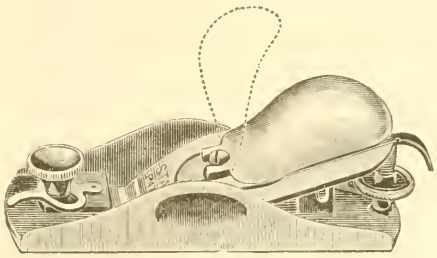


Fig. 8.

is made use of to cut across the end of material as shown in Fig. 9.

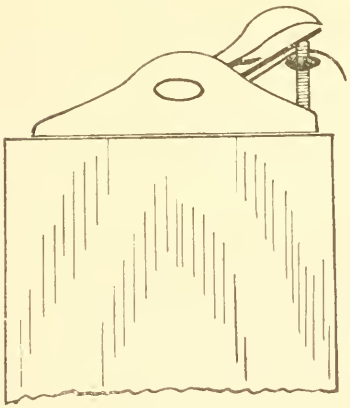


Fig. 9.

The chisel is a tool which can only be used successfully by practical experience and instruction. To pare smoothly with a chisel, it is necessary to understand the grain of the wood to be treated. In order to pare smoothly across the grain, the chisel edge should be held at an angle to the fiber of the wood, but the motion of the chisel should be directly across the grain. To pare end grain, the chisel should be given a motion across the end grain as well as a downward

motion, which may be understood better by a glance at Fig. 10. The chisel most convenient for this work, is 1½ inches

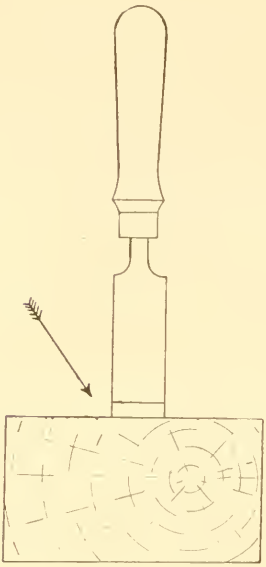


Fig. 10.

Fig. 10a.

wide. For mortising and dovetail joints, a bevel edge chisel is the best, and the chisel best adapted to the work must be selected. For bevel edge chisel see Fig. 10a.

The marking gauge is a tool for marking lines on the work, which must be parallel with the fiber of the wood.

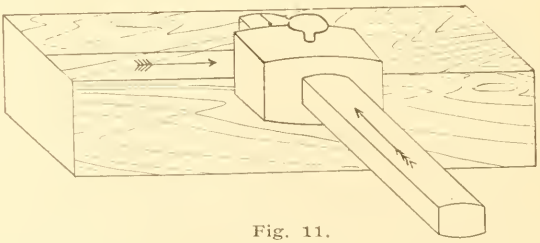


Fig. 11.

In the use of this tool great care must be taken to move the

gauge in the proper direction. The marking point on the gauge is liable to follow the grain or fiber, and the operator should observe the direction in which the grain or fiber runs and move his gauge accordingly. Fig. 11 will give an idea of the operation as it should be performed. The pressure should be applied as shown in diagram. If the gauge is moved in the opposite direction, it is plainly to be seen that the marking point on the gauge would follow the direction of the fiber and the line would not be parallel to the edge gauged from.

The try square is a tool used for squaring across the work and squaring the edges, or to determine when the edges are square. The most accurate manner in which to use the try square to determine the correct condition of an edge is to place it on the work as shown in Fig. 12. When the square

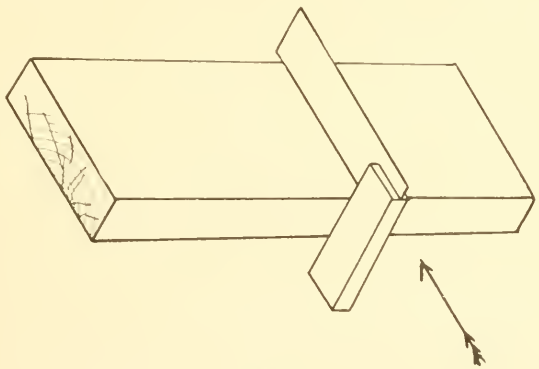


Fig. 12.

is placed on the work in this manner to determine the correctness of an edge, pressure should be put on the portion of the square as shown in the diagram, and with the pressure in this direction, move the square slowly downward until the blade comes in contact with the work at some point, which will determine the exact condition of the edge. The ordinary way of applying the try square to the work is shown in

Fig. 13. The advantage of the method as shown in Fig. 12 is that the long blade of the square in contact with the wide surface is a longer and a more accurate indicator.

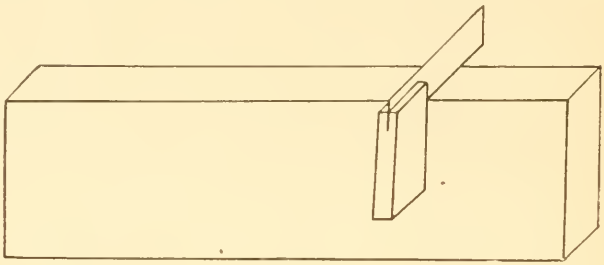


Fig. 13.

The bevel square is a tool used for the purpose of guiding the marker in making lines at an angle or obliquely across the work. The blade, being adjustable, may be set at any angle from one to ninety degrees. The bevel square is shown in position on the work in Fig. 14.

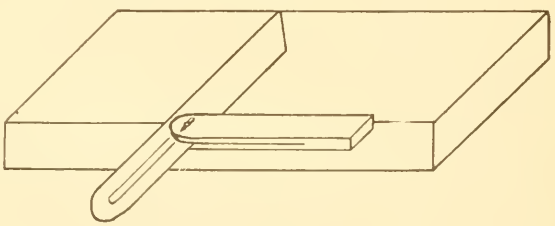


Fig. 14.

The hammer and screw-driver are tools which need no explanation as to their usefulness, but the latest and most improved patterns, such as the lightning and rapid transit screw-drivers, are much more convenient and expeditious. A word might be said here as to the manner in which a screw-driver should be fitted to the slot in the screw. The beginner will ordinarily fit a screw-driver as shown in Fig. 15. This is in extremely bad form. The best form is as shown in Fig. 16. This condition prevents the screw-driver from slipping out of the slot in the head of the screw with very little

downward pressure, while in the preceding figure it can be seen readily, that the driver would require great pressure, and, at the same time, be liable to slip out of the slot and

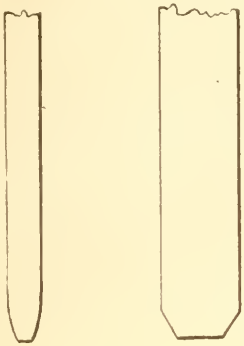


Fig. 15.

Fig. 16.

Fig. 17.

damage the head of the screw. The correctly fitted screw-driver and its position in the slot of the screw are shown in Fig. 17.

The back saw is a small saw, used for small work at the bench; such as joints, cutting off, etc., but cannot be used

Fig. 18.

for anything larger than two or three inches in thickness, and even at this thickness, a larger saw is more applicable. The back saw is shown in Fig 18.

The tools necessary for any purpose outside of those already mentioned are listed as general tools, and are kept in the tool room and can be obtained upon application to the instructor. Following is a partial list of the tools necessary for the various exercises, used in the carpentry course:

Crosscut saw. Rip saw.
Bit brace.
Auger bits (various sizes from 1/4 in. to 1 in)

Rabbet plane. Plough plane.
Oilstone. Slipstone.
Steel square.

The crosscut saw is used for the purpose of cutting across the grain or fiber of the wood. The teeth of a crosscut saw are of the shape shown in Fig. 19. The teeth are

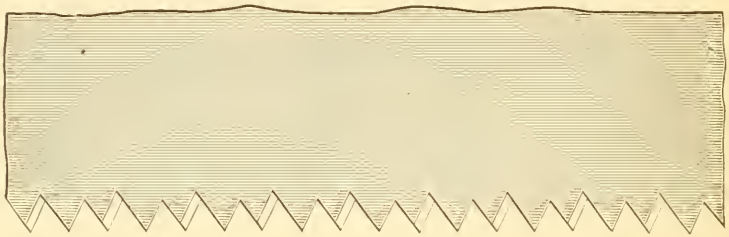


Fig. 19.

filed to a lance shape and are inclined somewhat toward the point of the saw. Every alternate tooth is inclined toward one side of the blade, so as to cut an opening slightly wider than the thickness of the blade. This is called *set* and provides clearance for the saw in passing through the wood. The rip saw is used for cutting parallel with the grain and has a differently formed tooth, see Fig. 20, and is filed di-

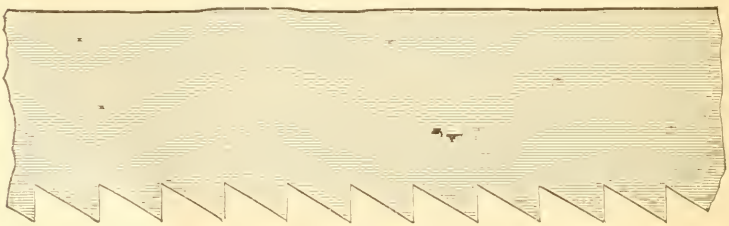


Fig. 20.

rectly across. The proper angle or rake for teeth of a rip saw may be determined by placing the try square on the points of the teeth, as shown in Fig. 21. The front side of the tooth should be at a right angle to the line of the points of the teeth; while in the crosscut, the test may be made by placing the try square on the back of the saw, as shown in

Fig 22. The front or cutting edge of the tooth should be parallel to the blade of the square. This rule is the best for

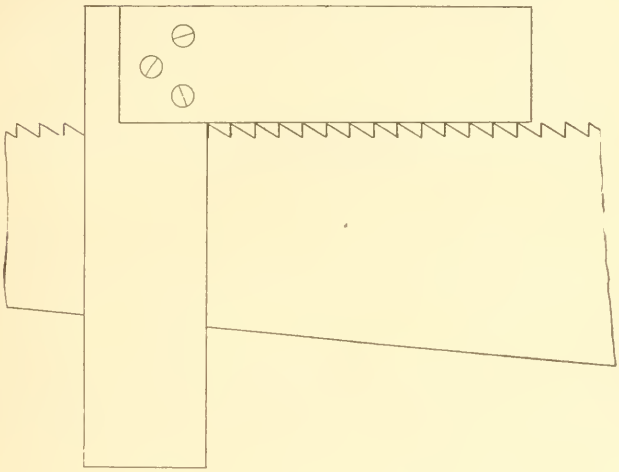


Fig. 21.

crosscut saws for general use, but gives somewhat more rake or angle than is suggested by some writers on the sub-

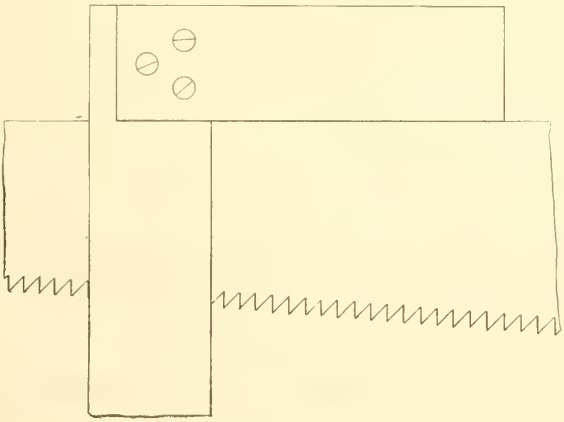


Fig. 22.

ject. It is evident that the more rake the saw tooth has,

the more freely it will cut, but with too much rake or angle it will not cut so smoothly. This rule, however, is one which meets with the approval of practical workmen, in general.

The bit brace will need no further explanation than is afforded by Fig 23. This tool is used to drive the auger or

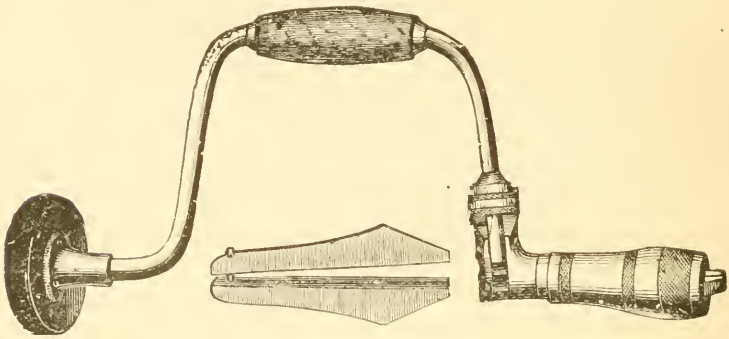
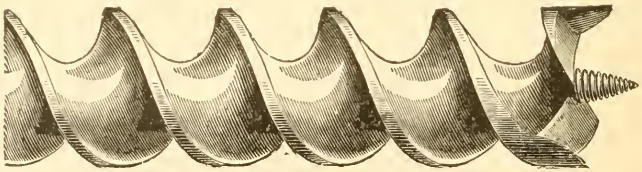


Fig. 23.

drill by hand, and to hold it in a fixed position while performing the work of boring. The various kinds of bits, made use of in wood working, are the

Auger bit.
Wood drill.
Center bit.
Expansive bit.
Bottom bit.

The various kinds are shown in Fig. 24.



Auger bit.

Wood drill.

Fig. 24.

Center bit.

Expansive bit.

Bottom bit.

Fig. 24 Continued.

The rabbet plane is shown in Fig. 25, and is used to plane out by hand such angles as are shown in Fig. 26. This plane

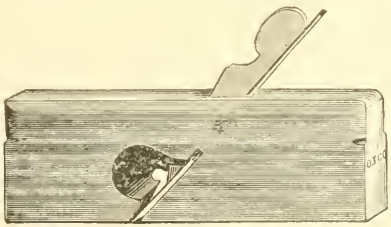


Fig. 25

is adapted to cutting parallel with the grain, but for cutting

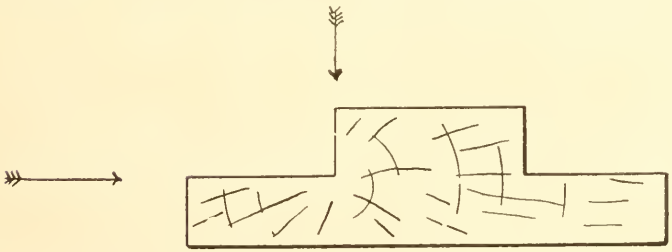


Fig. 26.

across the grain the fillister plane is best. This plane differs from the rabbet plane somewhat. The cutter is not set at a right angle to the plane, but is arranged obliquely across the bottom of the plane, thereby giving a skew cut. This is necessary to insure a smooth surface in cutting across the grain. It also has a spur or cutter projecting below the bot-

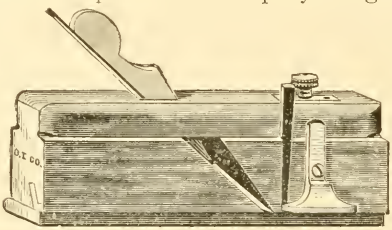


Fig. 27.

tom and in advance of the cutter proper and cutting in a parallel line to the motion of the plane to cut the fiber of the cross-grain. The fillister is shown in Fig. 27. A very conven-

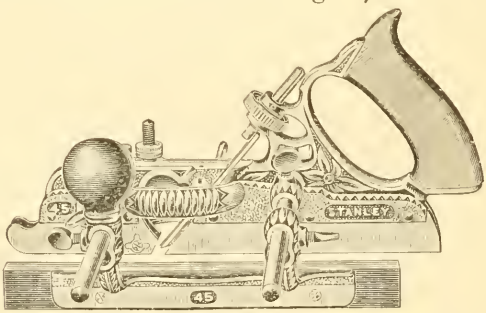


Fig. 28.

ient tool is the combination rabbet and fillister. This tool will perform the work of both. The plough plane is shown

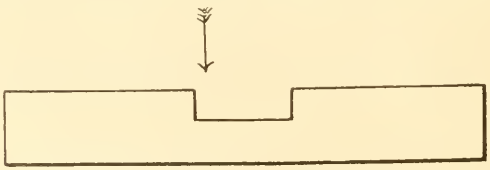


Fig. 29.

in Fig. 28 and is used in planing a groove or double angle, as shown in Fig. 29. This plane has cutters of various widths,

which may be adjusted in the plane to accommodate the work to be done. It also has a depth gauge in order to make the groove the proper depth. This gauge may be set and, when the limit has been reached, the plane will no longer cut.

The oilstone and slipstone will need no explanation as to their usefulness, after what has been said in regard to edged tools. The best quality of stones for the most expeditious sharpening is the red India oilstone, but for the finer and more smoothly cutting edge the Arkansas is the best.

The steel square is next to be considered. This tool is deserving of more than it is possible to find room for in this work; but an explanation of what is marked on the square, and what should be understood by every student will be all that will be spoken of in this connection. The square recommended and the one adopted for general use, is marked No. 100. This tool is very useful to the house carpenter, the stair builder, and the millwright; but it is almost indispensable to any mechanic, and should be understood by engineers in general. The square is shown in Figs. 30 and 31. The figures and graduations on the face of the square pertain to lumber measure, brace measure and a scale for laying out timbers to be made octagonal in form.

We will first consider lumber measure as shown in Fig. 30. A knowledge of its use may be obtained by a few moments' study and when once understood, is always at hand and ready for use. The following explanations are deemed sufficiently clear to give the student a full knowledge of the rule.

By examining Fig. 30, we will find under the figure 12 on the outer edge of the blade, the length of the board or plank to be measured, and the answer, in feet and inches, is found under the inches in width that the board or plank measures. For example; take a board 9 feet long and 5 inches wide, then under the figure 12 on the second line will In case the plane is placed on the work, as shown in Fig. 38,

be found the figure 9 which is the length of the board; then run along the line to the figure directly under the 5 inches, (the width of the board) and you will find 3 feet and 9 inches, which is the correct answer in board measure.

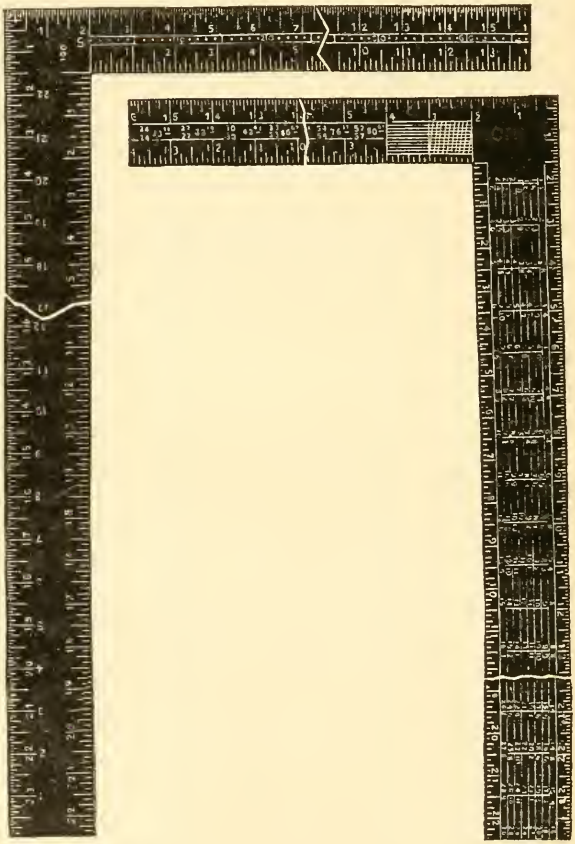


Fig. 31. Fig. 30.

If the material is two inches thick this result may be multiplied by two, and if three or four inches thick, multiply accordingly to get the proper solution in board or lumber measure.

If the material to be measured is longer than any figure shown on the square, it can be measured by dividing the length, and adding the results. The rule is calculated, as its name implies, for board measure or lumber one inch in thickness. It may be used in measuring timbers by multiplying the superficial measure of one surface by the thickness of the timber in inches. To illustrate; suppose a timber which is 10 inches by 14 inches by 25 feet is to be measured; for the length take 12 ft. and 13 ft.; for the width we will take 10 inches, and multiply the result by 14; by the rule a board 12 ft. long and 10 inches wide contains 10 ft.; and a board 13 ft. long and 10 inches wide contains 10 ft. 10 in.; therefore, a board 25 ft. long, and 10 in. wide, must contain 20 ft. 10 in.

In the timber measured, we have what is equivalent to 14 such boards and we multiply 20 ft. 10 in. by 14, which gives us 291 ft. 8 inches, the correct answer.

The brace rule is always placed along the center line of the tongue of the square, as shown in Fig. 30. This rule is easily understood. The figures on the left of the line represent the run or the length of two sides of a right angle, while the figures on the right represent the exact length of the third side of a right-angled triangle in inches, tenths and hundredths;—or, to put it in another way, the equal numbers placed one above the other, may be considered as representing the sides of a square and the third number to the right, the length of the diagonal of that square. The exact length of a brace, from point to point, having a rise of 33 inches and a run of 33 inches would be 46.67 inches. The brace rule varies somewhat in the matter of the runs shown on different squares; some squares give a few brace lengths of which the runs upon the beam and the rise on the post are unequal. The rise and run of a brace are shown in Fig. 32.

The octagonal scale is shown on the central division of the opposite side of the tongue from the brace rule and its use is as follows: Suppose a stick of timber ten inches square is

to be made octagonal; make a center line which will be five inches from each edge; set a pair of compasses, putting one point on any of the main divisions shown on the square in this scale, and the other point on the tenth subdivision;—this

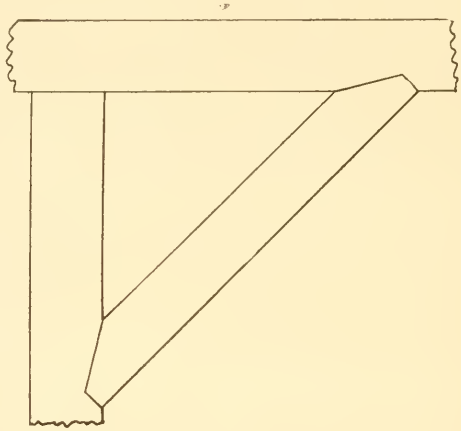


Fig. 32.

division marked off from the center line on each surface will give the points for the gauge line. Gauge from the corners both ways, and the lines for making the timber octagonal in its section are obtained. Always take the number of spaces or subdivisions in the scale to correspond with the number of inches square from the center line. Thus if a stick is 12 inches square, take 12 spaces on the scale; if only 6 inches square, take 6 spaces. The rule always to be observed is as follows: Set off from each side of the center line as many spaces by the octagon scale as the timber is inches square. For timbers larger in size than the number of divisions in the scale, the measurements by it may be doubled or multiplied as occasion may require. Fig. 33 shows an end of a timber, laid out by the above scale.

This scale is a very useful one, but a more convenient and simple rule is the following: To lay off a square timber to be made octagonal, place the square on one flat surface of the

timber in the manner shown in Fig. 34, take the scratch awl or pencil, and mark a point against the edge of the blade on

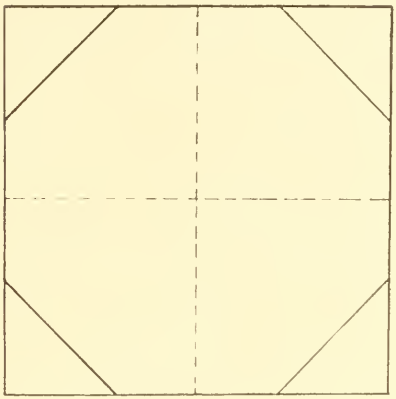


Fig. 33.

the surface of the timber at the seventh inch mark, and from the adjacent corner of the timber set the marking gauge to the

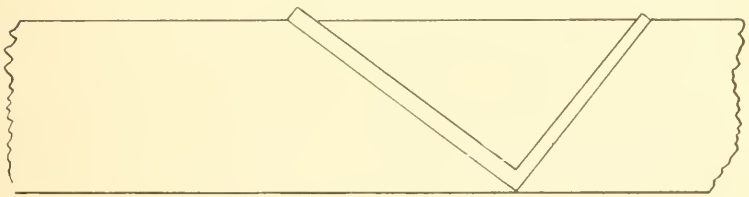


Fig. 34.

point marked at seven. From each corner gauge lines on each surface of the timber parallel with its length and when the corners of the timber have been worked off to the lines drawn, it will be octagonal in section.

The diagonal scale is on the tongue of the square at its junction with the blade as shown in Fig. 35 and is used for getting measurements to 1/100 inch. The lengths of the lines between the diagonal and the perpendicular are marked on the latter; primary divisions are tenths and the junction

of the diagonal lines with the longitudinal parallel lines enables the operator to obtain divisions of one hundredth parts of an inch. For example, if we wish to obtain twenty-four one hundredths, we place compasses on the dots on the fourth parallel line which covers two primary divisions and a fraction or four-tenths of the third primary division, which added together make twenty-four hundredths of an inch.

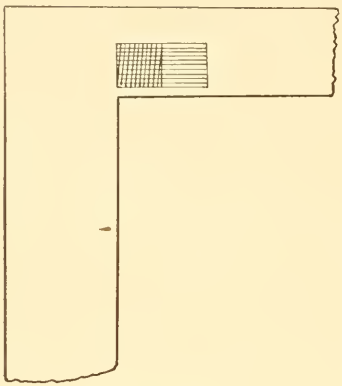


Fig. 33.

This scale is very easily understood and needs no further explanation. All other scales on the square are simply inches and divisions of an inch. There are many problems which can be worked out on the steel square, but those explained above are marked on the square aside from the inches and divisions of an inch, and are considered most important.

CARPENTRY.

Exercise No. 1.

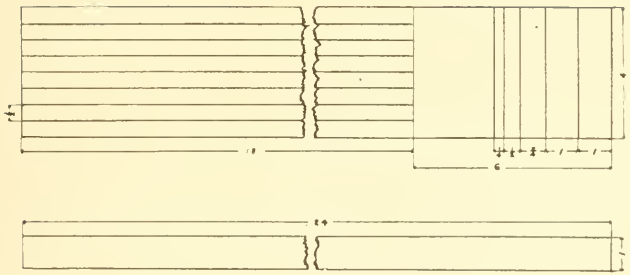


Fig. 36.

Exercise No. 1, is shown in Fig. 36 and consists of a parallel piece two feet eight inches in length, four inches in width, and one inch in thickness. The work should be conducted in the following manner. Place the material on the work bench and against the bench stop. Plane the rough surface of one side with the jack plane, after which, take the jointer or fore plane and true the surface up, making it a true plane.

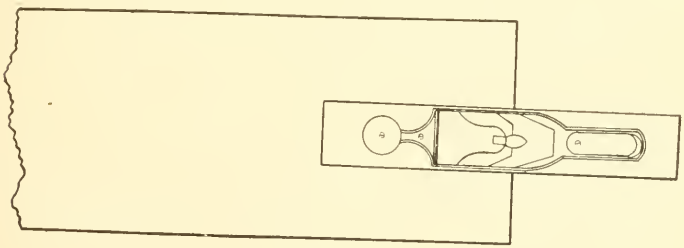


Fig. 37.

This may be accomplished more expeditiously by observing the following rules. Move the plane on a line parallel with the length as shown in Fig. 37 and not as shown in Fig. 38.

the result will be invariably a warped or twisted surface. Another point to be given consideration is the pressure downward

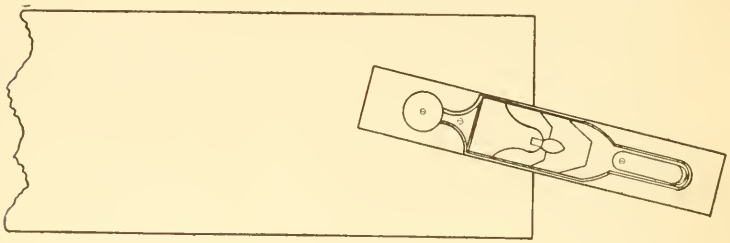


Fig. 38.

on the plane while the operator is moving it ahead in a line with the work upon starting the plane to cut as shown in Fig. 39. The downward pressure should be applied on the

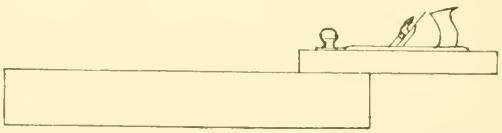


Fig. 39.

front handle of the plane, and, as the tool is moved along toward the other end of the work, the pressure should be only on the rear handle, as shown in Fig. 40. No pressure should

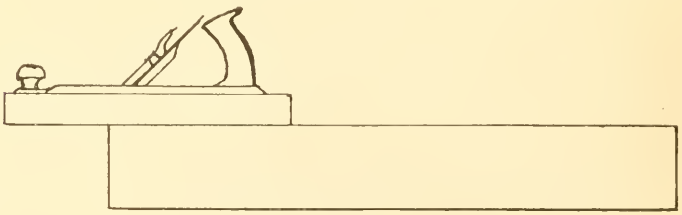


Fig. 40.

be applied to the end of the plane which overhangs the end of the piece of work; for when pressure is put on the overhang-

ing end the result cannot be otherwise than a rounded surface, as shown in Fig. 41, so that while the operator is striving to get a true surface, he is making it more untrue.

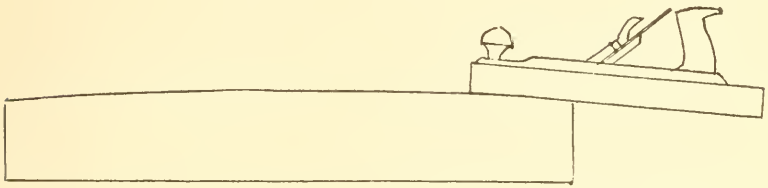


Fig. 41.

A beginner is very liable to make the surface warped or winding, and, his eye being untrained in the work, he finds it hard to decide when the surface is correct. In order to prove a surface use the steel square as a straight edge. Place it parallel with edge of the work, to decide when work is straight; and place it diagonally across to determine as to a warped surface, as in Fig. 42. If the square fits in all directions the surface is true.

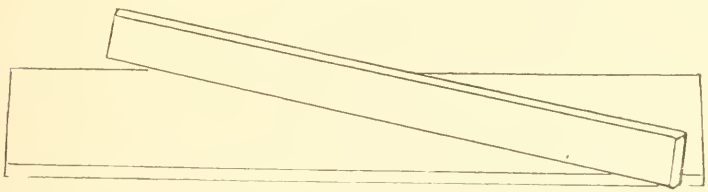


Fig. 42.

The parallel rules or two steel squares may be used to prove the surface in the manner shown in Fig. 43. When placed in this position, look across the top of the rules lengthwise with the work, and if the top lines of the rules appear parallel there is no warp in the surface. To prove it by the eye requires training. A skilled workman can decide at a glance by looking along the surface lengthwise, and raising the end nearest

the eye until the top surface disappears, and by comparing the lines of the ends as shown in the following sketch, No. 44. If

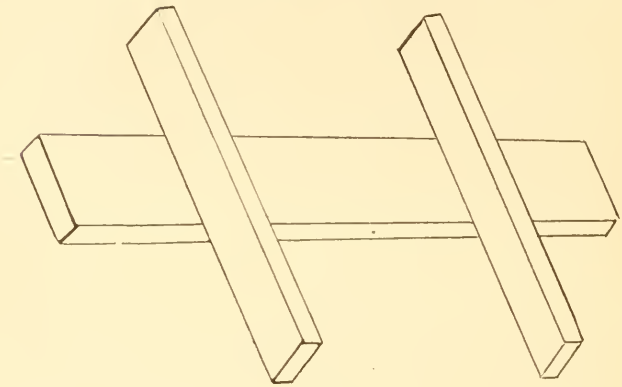


Fig 43.

the lines of the two ends appear parallel, there is no wind or warp in the surface. After the piece is finished, so far as

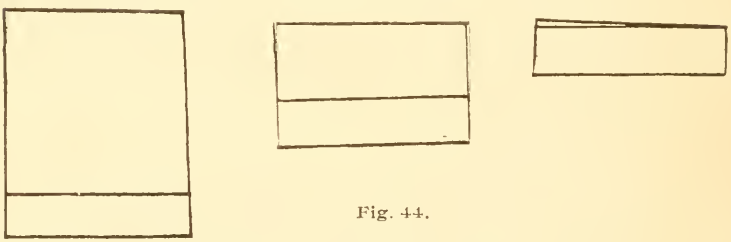


Fig. 44.

planing is concerned, the numbered surfaces will appear as shown in Fig. 45.

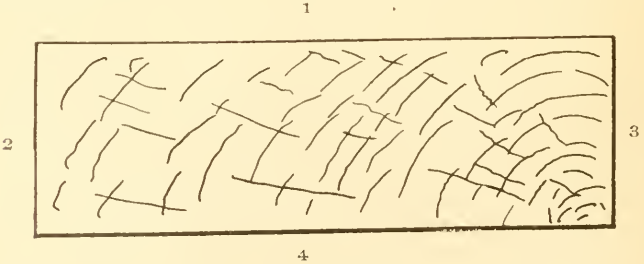


Fig. 45.

After the first surface has been made perfect, it should be marked No. 1. After this has been done, an adjacent edge should be made straight and square with No. 1. This surface should be marked No. 2. The corner or angle formed by surfaces Nos. 1 and 2 constitutes the working line or edge from which all gauging and squaring should be done. With the marking gauge make a line on surface No. 1 four inches from the working edge, using that edge as a guide for the gauge. Place surface No. 2 downward on the bench and plane the third surface down to the line, at the same time making it square with surface No. 1, which will make the piece four inches in width. This surface should be marked No. 3. Both Nos. 2 and 3 must be squared to No. 1. The gauge should next be set to the thickness of the required piece, and a line be drawn on surfaces Nos. 2 and 3, using surface No. 1 as a guide for the marking gauge. Place surface No. 1 downward and proceed to plane the fourth surface to the lines drawn on Nos. 2 and 3; this may be done more easily by planing on one edge as shown in Fig. 46 and, when the line has

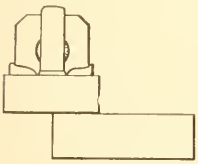


Fig. 46.

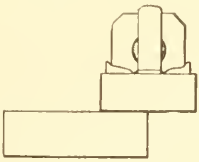


Fig. 47.

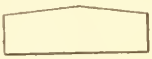


Fig. 48.

been reached on this edge, transfer to the other edge and plane to the line on this edge (see Fig. 47) which will leave the surface high in the center as shown in Fig. 48. Next transfer the plane to a central position and plane the center down to a straight line across, planing nothing off at the extreme edges which may be proven by applying the try square as shown in Fig. 49. This surface is to be marked No. 4. If the work has been done properly, the opposite surfaces of the piece will be parallel.

To lay out the lines on the piece as shown in Fig. 36 it is best to proceed in the following manner. Place the try square across surface No. 1 near the end, with the body of the square against surface No. 2, and with the body of the

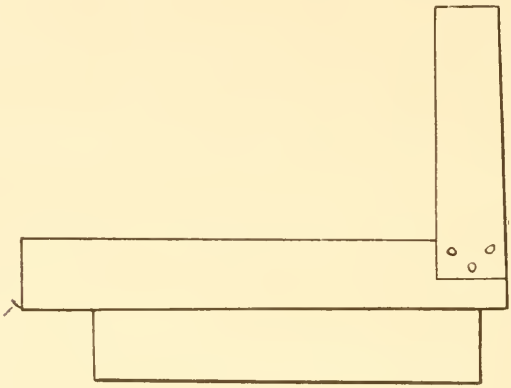


Fig. 49.

square held firmly against this edge, mark with the point of a knife a line across surface No. 1 and exactly parallel to the blade or tongue of the square. This is the end line from which all measurements running lengthwise with the piece must be taken. Six cross lines are drawn across in the same manner. The distances from the end line —

1 in.
2 in.
2¾ in.
3¼ in.
3½ in.
8 in.

The other end line is then drawn two feet from the eight inch cross line. These lines are then to be squared around the piece always placing the try square on surface Nos. 1 or 2. After the cross lines are made the marking gauge must be used in marking lines on surfaces Nos. 1 and 4 lengthwise of the piece one-half inch apart from the eight inch line to the

last end, using surface No. 2 as a guide for the marking gauge. The cross lines are to serve as a guide in sawing for the crosscut saw across, and the longitudinal lines as a guide for the rip saw. The ends should be sawed off next, being careful to have the saw cut come outside the line, and not over its center. Otherwise, the piece will be shorter than the required length. Next cut to the 2nd, 3rd, 4th, and 5th lines in the same manner as the first, keeping on the same side of each. Do not cut through the piece but leave one-eighth of an inch in thickness uncut. The rip sawing is next to be done, sawing on

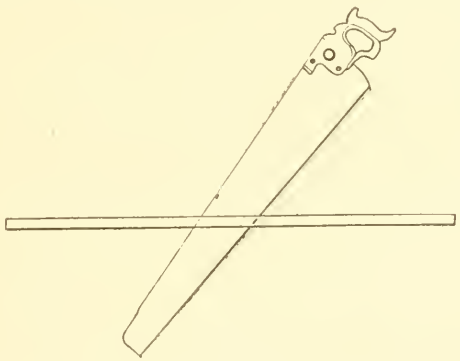


Fig. 50.

the same side of each line, the saw cutting only to the center of the line. The rip saw should be used at about the angle shown in Fig. 50 and not as in Fig. 51. It may be seen readily that the

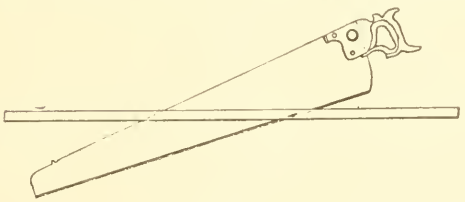


Fig. 51.

saw is cutting through less material in Fig. 50 than in Fig. 51, that is to say, when a piece one inch in thickness is being ripped if the saw is held at an angle of 75 degrees the line of contact

of teeth would be about one and one-fourth inches, and in case it is held at 35 degrees it would be cutting through about two and one-half inches. Great care should be taken to keep the sides of the saw at a right angle to the surface of the piece, so as to follow the line on the bottom or fourth surface, the same as on the top side or surface No. 1.

EXERCISE NO. 2.

Exercise No. 2 is shown in Fig. 52 and is used on the bench to place the work on while sawing small pieces and is called a bench hook. In this exercise the use of the planes, try square,

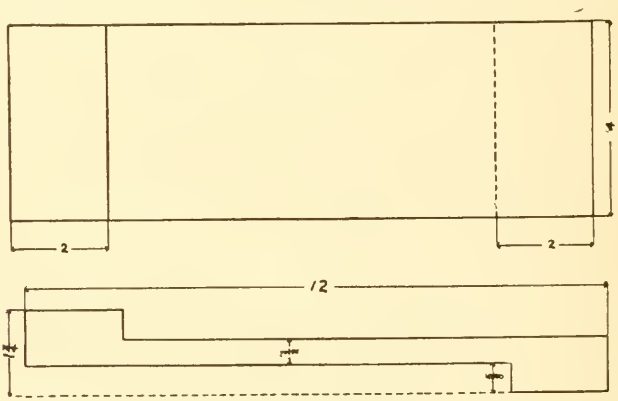


Fig. 52.

knife, marking gauge, saws, and the paring chisel is necessary. The work should proceed in the following order: plane up a piece 12¼ inches long, four inches wide and one and three-fourths inches thick, in the same manner as in exercise No. 1, numbering the surfaces in the same order. After this is done, draw a line with a knife near the end and measure with the rule from this line to the try square two inches and draw another line across; then another ten inches from the first

line and next twelve inches from the first line, this will be the end line. Square all these lines around the piece. Set the marking gauge at 5/8 inch and gauge a line on each edge of the piece, using surface No. 1 as a guide for the gauge. Next set the gauge at 1⅛ inches and draw a line on each edge from surface No. 1. Fig. 53 shows the material to cut away. Next

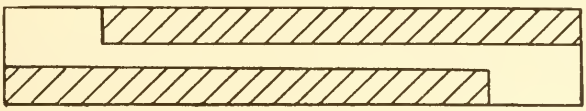


Fig. 53.

use the rip saw and cut 1/16 inch away from the line so as to leave material for dressing smooth with the chisel. Rip down near to the 10 inch line on either side, keeping at the same distance from the line on each edge. Next take the back saw, and cut in the same manner as you have done the ripping 1/16 inch from the line. Cut off the ends with the back saw exactly to the line. The 1½ inch paring chisel is next used to true and smooth the sawed surfaces to the lines. The end grain should be pared first, following the line on the top surface with the chisel, and the short lines on the edges afterward. Lastly cut down the middle of the surface. For the flat surface place the piece on edge, and, with the chisel held in one hand, and the work held in position with the other, pare to the line and across the grain, leaving the flat surface still high in the center. After this, place the piece in the vise and pare the central portion down to a straight line across. Do not pare lengthwise with the grain of the wood. Test the surface with the try square. This being the first exercise where the paring chisel is necessary, great care should be taken not to cut too deep, but while paring across put considerable downward pressure on the chisel with one hand, and do not allow the handle to rise or the cutting edge to dig in. If this occurs the piece will be spoiled.

EXERCISE NO. 3.

Exercise No. 3 is shown in Fig. 54 and should be done in the following manner. Plane out a piece of material 13 inches long and 1⅝ inches square, numbering the surfaces as

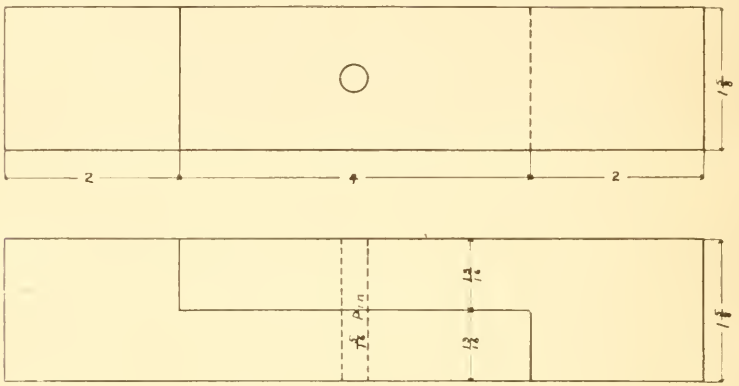


Fig. 54.

before. With the try square and knife draw a line at the end, and with the rule measure off the length of the splice from the first line to the try square and draw the other line. Do the same on the other end and square all lines around the piece.

Set the marking gauge at 13/16 inch and gauge a line on surfaces Nos. 2 and 3, using surface No. 1 as a guide for the gauge. Fig. 55 shows the portion to be cut away. The

Fig. 55.

saw is now to be used to cut out the shaded portion. Cut away from the line 1/16 inch and pare down to the line with the paring chisel and make all surfaces smooth. After this is done, the piece must be taken to the instructor, to be cut

into two parts and put together. The marking of the joint will be according to its correctness. After the workmanship has been considered by the instructor, the two pieces must be fastened together with a wooden pin 5/16 inch round at the center of the joint.

EXERCISE NO. 4.

Exercise No. 4 is a right angle joint. See Fig. 56. The work must be done in the following manner. A piece of material 11 inches long is to be planed out 1⅝ inches square,

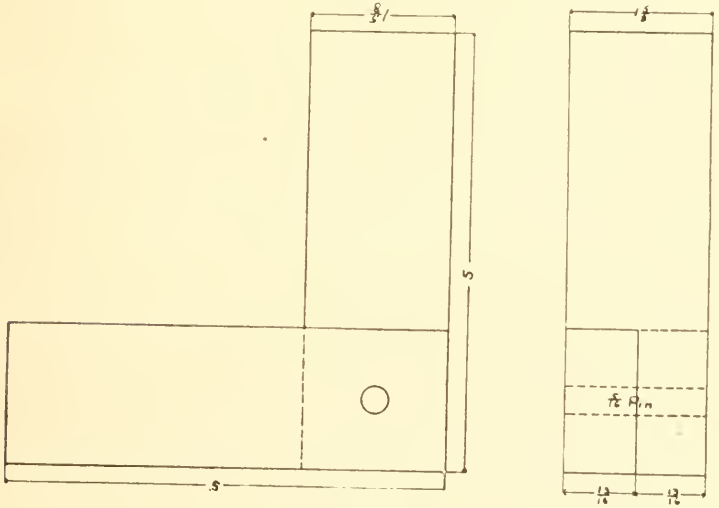


Fig. 56.

the surfaces to be numbered as in the preceding exercises. Place the try square across the piece 1⅝ inches or more from the end, with the body of the square held against surface No. 1 or 2. Draw a line with the knife. Square this line around the piece. Treat the other end in the same manner. Next set the marking gauge to one-half the thickness or 13-16 inch and gauge a line, using surface No. 1 as guide for the gauge,

on Nos. 2 and 3 lengthwise of the piece extending from each end to the cross lines drawn. Next saw out the shaded portion, as shown in Fig. 57. Saw 1-16 inch from the line

Fig. 57.

as before and pare to the line with the paring chisel. After this the piece is to be submitted to the instructor to be sawed in two pieces and a mark given on workmanship. After this the two pieces are to be put together at right angles and a 5-16 inch pin put through the joint to hold them in place. The ends projecting at the angle of the joint may be dressed down to an even surface, the length of the ends being measured off from the angle of the joint. Draw a line around and saw the ends to the line using the back saw. No dressing of the outside surfaces is to be done after the work has been marked out and joined together. All surfaces should be straight and true on the joint if the work has been properly performed.

EXERCISE NO. 5.

Exercise No. 5 is a joint similar to No. 4, but the angle of

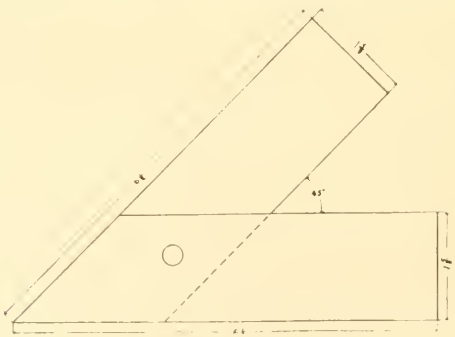


Fig. 58.

the joint is 45 degrees as shown in Fig. 58. The work of

planing out the piece 1⅝ inches square and 14 inches long is to be done in the same order as in the preceding exercise. The bevel square is to be set at an angle of 45 degrees, which may be done easily by placing the body of the bevel against the edge of the blade of the steel square with the tongue of the bevel extending across the angle of the square as shown in Fig. 59. Adjust the tongue of the bevel so that one edge of

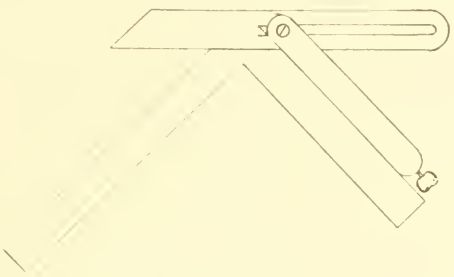


Fig. 59.

the tongue is the same number of inches from the angle of the square on either edge. Next place the bevel on the piece to be laid out, with body of the bevel held firmly against surface No. 2 and the blade or tongue of the bevel back about 2½ inches from the end. Draw a knife mark along the blade of the bevel on surface No. 1. Repeat this operation on the opposite end, drawing the line on surface No. 4. Square the lines across surfaces Nos. 2 and 3 and at termination of the oblique lines across surfaces Nos. 1 and 4. Next set the marking gauge at 13-16 inch and mark lines lengthwise of piece from the ends past the cross lines on surfaces Nos. 2 and 3, using surface No. 1 as a guide for the gauge. Next saw outside the lines and pare the surfaces to the lines and in a straight line across. When this has been done, the piece will appear as shown in Figs. 60 and 61. The work is now

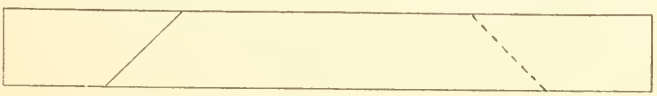


Fig. 60.

to be cut into two parts at the center by the instructor and marked according to workmanship. The pieces are then placed in position and bored and pinned together with a 5-16 inch

Fig. 61.

round pin, to hold them in place. The pin should be placed on the center line of the angle and on a line at a right angle to the shoulder of the joint, as shown in Fig. 62.

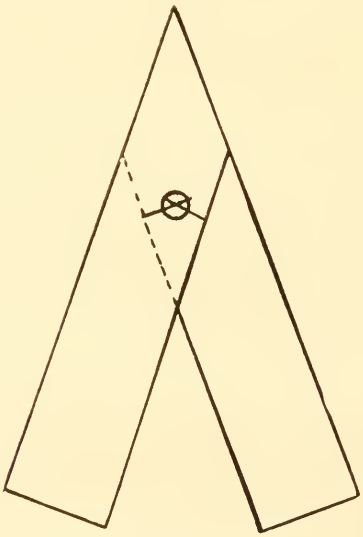


Fig. 62.

EXERCISE NO. 6.

Exercise No. 6 is a model of a timber splice, and is shown in Fig. 63. This joint is adapted for use where the stress is in two directions only. The work should be done in the fol-

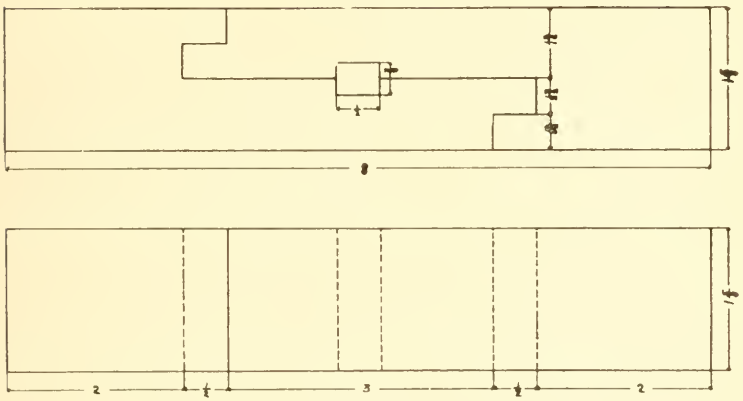


Fig. 63.

lowing manner. First plane a piece to the dimensions given, following the rules as in Exercise No. 1. With the try square and knife draw a line across the end of the piece. With the try square on surface No. 1 or 2, square this line around the piece. With end of the rule placed against the tongue of the square move the try square back along the working edge until the ½ inch mark on the rule meets the end line first drawn. With the knife mark a line here. Then move the square back until the 3 ½ inch mark on the rule meets the first line. Draw a line at this point. Next move the square back until the 4 inch mark on the rule is reached, and draw the last line. Square all these lines around the piece and repeat the operation on the other end of the piece, beginning with the end line as before. Next set the marking gauge at 13-32 inch and

gauge a line on surfaces Nos. 2 and 3 as shown at A, Fig. 64. Reset the gauge at 13-16 inch and gauge a line on the same surfaces as at B. Again, re-set the gauge at 1 7-32

Fig. 64.

inches and gauge lines on the same surfaces as at C. Next saw out the shaded portion of the piece, sawing near to but not on the line and pare to the lines with the paring chisel, being careful not to pare below the center of any line. After this has been done the piece is to be cut into two parts by the instructor and a mark given according to the correctness of the work. If the joint is well made and is a good fit, the work is to be pressed firmly together endwise in the vise and the key way laid out on each side. Work out the key way with the chisel, put the work together again and put the key in place. After the joint has been keyed up, the measurements from the ends of the joint to the end line are made and squared around the piece and the ends sawed off to the lines.

EXERCISE NO. 7.

Exercise No. 7 is a model of a pump rod joint and is shown in Fig. 65. This exercise appears very simple but the work must be done with great care and accuracy, to produce

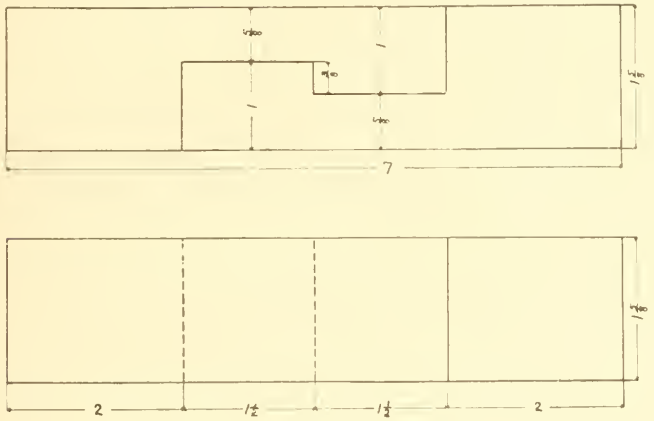


Fig. 65.

a good joint. Proceed in the following manner: Plane a piece to dimensions given, observing rules as in Exercise No. 1. Lay out end line and measure from that for the next line, as explained in Exercise No. 6. Measure from the first line for the distance to the third line. Square these lines around the piece, and repeat this operation on the opposite end of the piece. Next set the marking gauge at 5/8 inch and mark line as designated by A in Fig. 66 gauging from surface

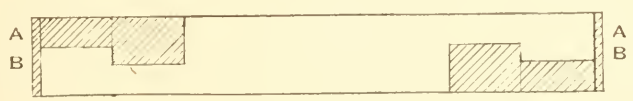


Fig. 66.

No. 1 and marking the line on surfaces Nos. 2 and 3. Re-set the gauge at 1 inch and gauge a line from surface No. 1 on Nos. 2 and 3 as at B. Next saw out shaded portion and pare

to the lines, with paring chisel as done in the preceding exercise, after which the piece must be cut into two parts by the instructor, and placed together. If the work has been properly and accurately done, the joint will remain in its position without further fastening.

EXERCISE NO. 8.

Exercise No. 8 is a model of a joint, designed to withstand stress or strain in four directions, and is shown in Figs. 67 and 68. This joint cannot be made to fit and at the same time

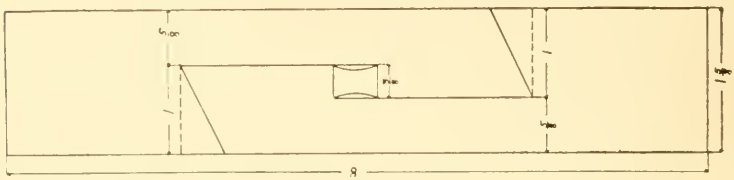


Fig. 67.

have correct dimensions without observing the following rules: Plane a piece of the required length and correct size,

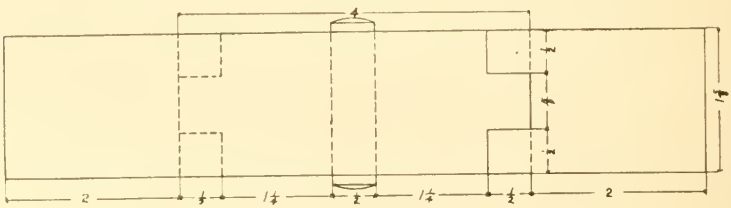


Fig. 68.

making opposite surfaces exactly parallel, and angles square, all surfaces being squared to No. 1. Begin by laying out an end line as in Exercise No. 6, getting correct measurements from the first or end line for all cross lines. Square these lines around on all sides and repeat the operation on opposite end of piece. Next set the marking gauge at 5/8 of an inch

and gauge lines as shown at A in Fig. 69, using surface No. 1 as a guide and marking the lines on surfaces Nos. 2 and 3. Next re-set the gauge at one inch and mark lines on same sur-

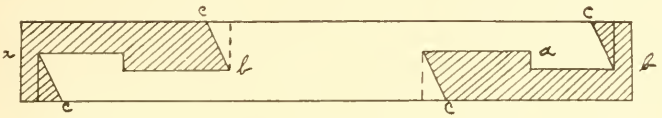


Fig. 69.

faces from No. 1 as shown at B. Then set the bevel at the second line on surface No. 1 and the tongue of the bevel intersecting the junction of the cross line No. 1 and the line drawn parallel to and one inch from surface No. 1. Draw a line along the tongue of the bevel as shown at C in Fig. 69. With this setting of the bevel all the oblique lines on surfaces Nos. 2 and 3 may be drawn, the body of the bevel resting on surface No. 1. The marking gauge is next set at ½ inch and lines drawn on surfaces Nos. 1 and 4, using surface No. 2 as a guide. See A in Fig. 70. The gauge is next set at 1⅛

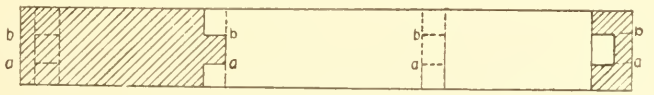


Fig. 70.

inches and lines drawn parallel to lines A using surface No. 2 as a guide. These lines in conjunction with the cross lines form the outline of the mortise and tenon at the end of the joint. See B-B in Fig. 70. The shaded portion is next to be sawed and pared out as in Figs. 69 and 70, when the piece is to be submitted to the instructor for inspection and to be cut into two parts and put together. After this is done the key is to be put in, the end lines are to be marked off, and the ends of the piece cut off to the lines, with the back saw, when the work is finished.

EXERCISE NO. 9.

Exercise No. 9 consists of a simple mortise and tenon joint as shown in Fig. 71 and 72. The work is to be done in the following manner: First plane a piece 1⅝ inches square, of

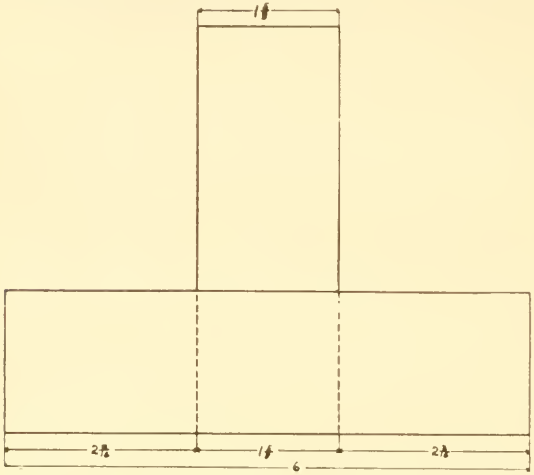


Fig. 71.

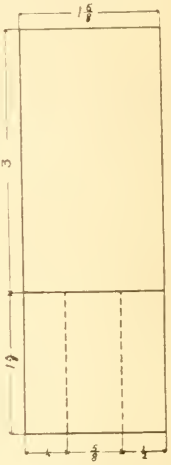


Fig. 72.

required length, observing the rules as specified in Exercise No. 1. With the knife and try square lay out lines across the piece as shown at A in Fig. 73, squaring the lines across from surface No. 1. Square these lines around the piece.

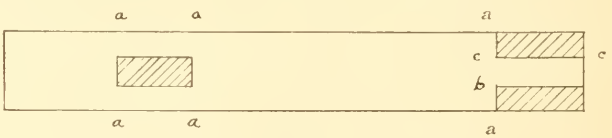


Fig. 73.

Next set the marking gauge at ½ inch and gauge lines on surfaces Nos. 2 and 3 using surface No. 1 as a guide for the gauge. See B in Fig. 73. Next set the marking gauge at 1⅛ inches and mark lines parallel to lines B as shown at C. Take the back saw and saw out and pare the shaded

portion to the lines A, B, and C. This forms the tenon. Next take a brace and a ½ inch auger bit, and bore holes half through the piece on surfaces Nos. 2 and 3 on shaded portion, see Fig. 73. With the 1½ inch and ½ inch paring chisels, pare to the lines of mortise, after which the work must be inspected by the instructor and cut into two parts, and put together, forming the mortise and tenon, shown in Figs. Nos. 71 and 72.

EXERCISE NO. 10.

Exercise No. 10 consists of a double mortise and tenon joint as shown in Figs. 74 and 75. The work in this exercise is practically the same as in Exercise No. 9, but the mortise

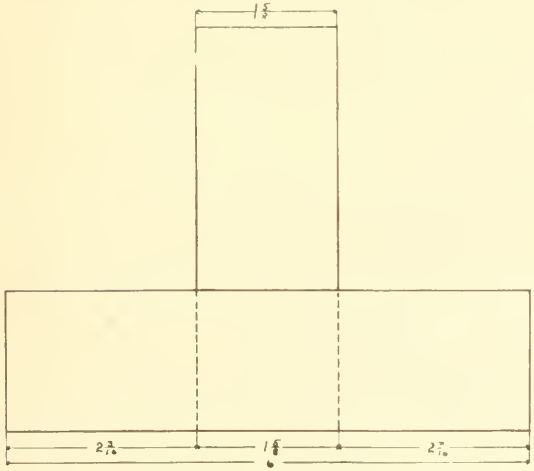


Fig. 74.

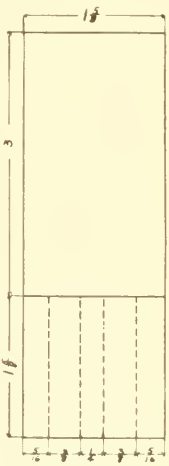


Fig. 75.

and tenon are double. The lines must be laid out in the same manner and from the working surfaces, but the setting of the gauge is for different dimensions. The cross lines are the same and are squared around the piece. The setting of the gauge is as follows: 5-16 inch, 11-16 inch, 15-16 inch and

1 5-16 inches, as shown in Fig. 76, at A, B, C, and D, the gauging being from surface No. 1 on Nos. 2 and 3. Next remove

Fig. 76.

with the saw, auger bit, and paring chisels, the shaded portions, when the work is ready to be inspected, sawed into two parts, and put together by the instructor.

EXERCISE NO. 11.

Exercise No. 11 is a dove-tail mortise and tenon joint and is shown in Figs. 77 and 78. The work should be done as follows: Plane a piece as described in Exercise No 1 to

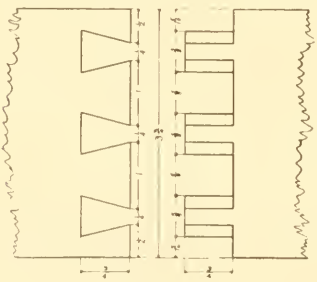


Fig. 77.

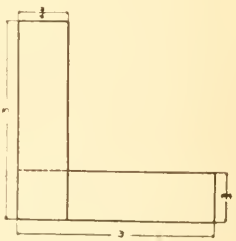


Fig. 78.

dimensions ¾ inch by 3¾ inches by 7 inches. With the block plane, square the ends to surfaces Nos. 1 and 2. Place the try square on surface No. 2 with the blade or tongue extending across No. 1, ¾ inch from the end. Draw a line and square it around the piece. Repeat this on the opposite end. Next set the marking gauge at 5-16 of an inch and mark a line on surface No. 4, at one end of the piece, from the end to the ¾ inch line, using surface No. 2 as a guide. Next set the marking gauge at ½ inch and gauge a line on surface No. 1, from the end to

the ¾ inch line. Without re-setting the gauge, mark a line on the opposite end on the end grain, using surface No. 2 as a guide. See Fig. 79 at A. Next set the gauge at ¾ inch and mark lines as at B. Re-set the gauge at 1¾ inches, and mark lines at C. Set the gauge at 2 inches and mark lines at D.

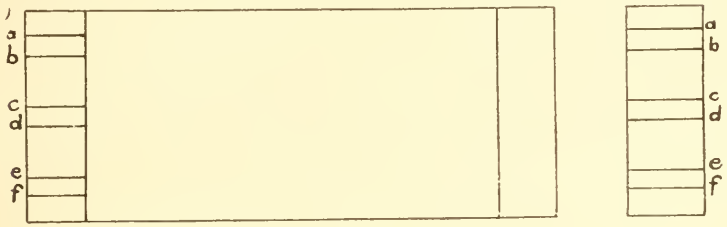


Fig. 79.

Set the gauge next at 3 inches and mark lines at E. Re-set the gauge at 3¼ inches and mark lines at F. Next place the bevel square across the end on surface No. 1, the tongue of the bevel resting on the end grain. Adjust the tongue so as to meet the first lines drawn on surfaces Nos. 1 and 4. Draw a line here with the knife. This setting of the bevel is to serve for all the other oblique lines of the mortise and tenon. The bevel is next to be placed so as to meet all the gauge lines drawn on either end and lines are to be marked with the knife. Next the try square may be placed on the end and lines marked with the knife parallel to the first gauge line and intersecting the oblique lines on the end grain. The piece will then appear

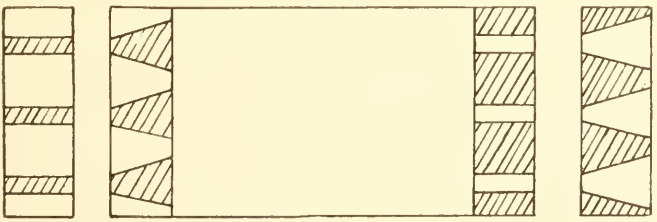


Fig. 80.

as in Fig. 80. The shaded portion is to be cut away. Pare

strictly to the center of all lines. Then the piece is to be submitted to the instructor for his inspection, and to be cut into two parts and put together.

EXERCISE NO. 12.

Exercise No. 12 is a dove-tail mortise and tenon joint ordinarily used by cabinet makers on front corners of drawers, and is called a drawer dove-tail joint and is shown in Fig. 81. The manner of procedure in this exercise is as follows: Plane two pieces of material for the joint, one piece to be

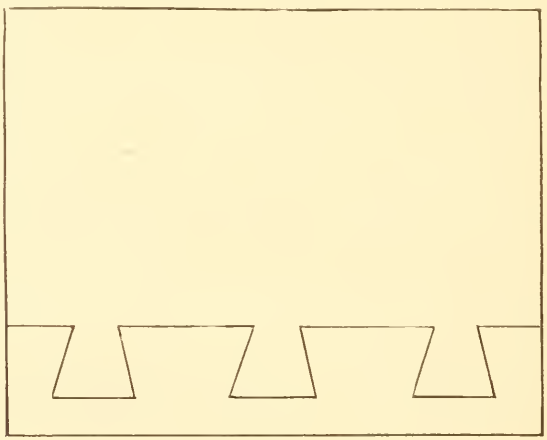


Fig. 81.

¾ inch by 3¾ inches by 4 inches. The other to be ½ inch by 3½ inches by 4 inches. Next square one end of each piece and on the piece ½ inch thick mark a line on surface No. 2 as a guide. Square this line around the piece. Next set the marking gauge at 5-16 inch and gauge a line on the end grain of the squared end, using surface No. 2 as a guide. Then set the gauge at 15-16 of an inch and gauge a line on the same surface with No. 2 as guide. Re-set to 1-9-16 inches and gauge another line on the same surface. Next

set the gauge at 2 3-16 inches and mark another line from surface No. 2. Re-set at 2 13-16 inches, and mark another line on the same surface. With another setting of the gauge at 3 7-16 inches, gauge the last line. Then set at ½ inch and using surface No. 2 as a guide, with the marking gauge mark a fine line on surface No. 1, crossing the first line drawn with the try square and knife. Next place the bevel square on the end grain and adjust the tongue of the bevel so as to intersect the first line drawn on the end grain and the fine line on No. 1. This adjustment of the bevel will serve as a guide to mark all the lines on surfaces Nos. 1 and 4, starting from the lines on the end grain and meeting lines squared around the piece from No. 2, after which the piece will appear as in Fig. 84. Next saw and pare out with the chisel the shaded

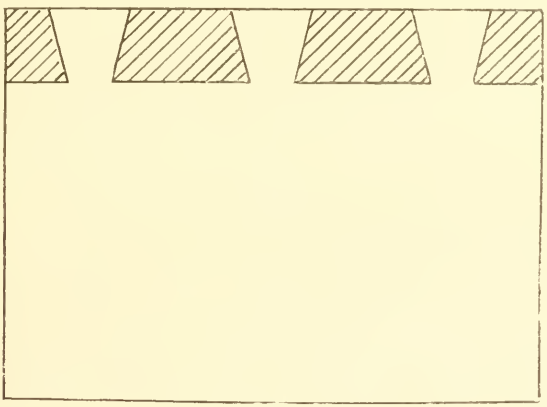


Fig. 84.

portion and keep well to the center of the lines in paring. Next square a line on the ¾ inch thick piece on surface No. 1 from No. 2, and ½ inch from the trued end. Next place the ¾ inch piece in a firm position with the dressed end up and place the ½ inch piece on the end grain, with the ½ inch line even with surface No. 1 of the piece as shown in Fig. 85. Hold firmly in this position and with a knife mark outlines of

the dove-tails on the end grain. Next square the lines on No.

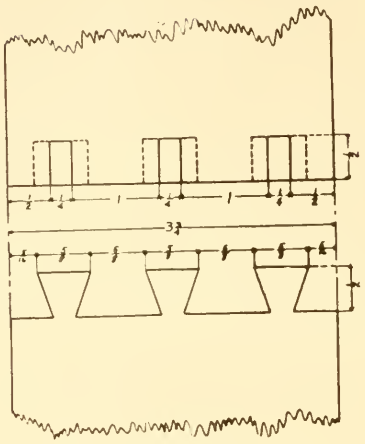


Fig. 85.

1 with the try square and knife, from the lines on the end to the ½ inch line, when the piece will appear as in Figs. 86 and 87. The shaded portion is next to be cut away with

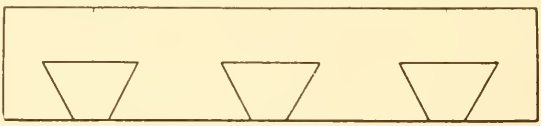


Fig. 86.

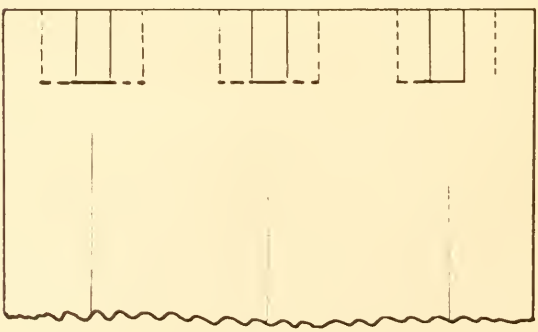


Fig. 87.

the paring chisels and tools and put together by the instructor

and if the work has been properly executed a good joint will be the result, and all outside surfaces will be tangent, and the joint will appear as in Fig. 81.

EXERCISE NO. 13.

Exercise No. 13 is a framed panel as shown in Fig. 90. The construction is to proceed in the following manner: Plane two pieces, ¾ inch by 1¾ inches by 22 inches, proceeding

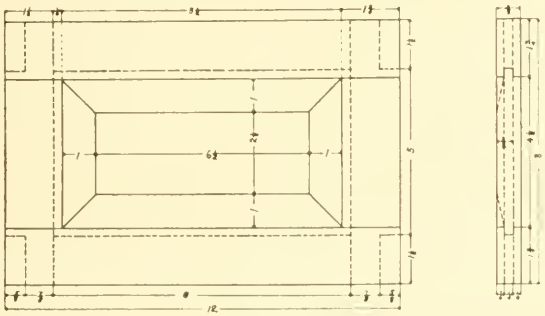


Fig. 90.

in the same manner as in Exercise No. 1. Next place surfaces No. 4 of these pieces together and surface No. 2 of each piece uppermost, and place them in the vice together. Square lines across the pieces while in this position, indicating the cross lines of the mortises and the shoulders of the tenons as shown at A in Fig. 91. Square all these lines around the pieces. Next set the marking gauge at ¼ inch and gauge B on both pieces on surfaces Nos. 2 and 3, using surfaces No. 1 as guides for the gauge. Re-set the gauge at ½ inch and gauge lines on the same surfaces from No. 1 and parallel to the first gauge lines drawn. The shaded portions are now to be cut away with the saw and paring chisel on the tenons, and with the auger bit and mortising chisel in the mortises. Cut to the lines on surfaces Nos. 2 and 3; afterward straighten surfaces

through. Next with the plough or circular saw cut a groove

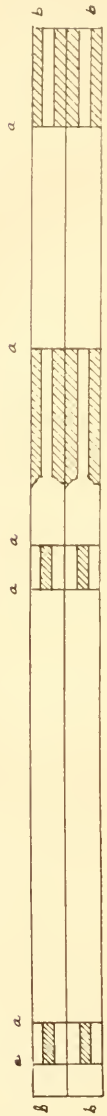


Fig. 91.

Fig. 92.

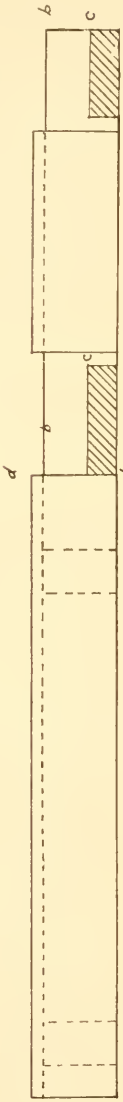


Fig. 93.

¼ inch deep on surface No. 2, of each piece, the outlines of

which must be even with the lines of the mortises and tenons, when the pieces will appear as in Figs. 92 and 93. With the marking gauge next mark lines on the sides of the tenons at A in Fig. 93 from edge of tenon marked B as guide. Next with the knife and try square mark lines across the side of tenons as at C, ¼ inch from the shoulder to the tenon, and cut away the shaded portion of the tenon with the saw and paring chisel. Next cut the pieces in two parts at D and they are ready to be put together. Plane a piece for the panel, ½ inch by 5 inches by 9 inches. Bevel the edges of the piece on surface No. 1 to a gauge line drawn around the piece, using the four edges as a guide for the gauge and to a thickness which will allow the panel to enter the grooves in the frame and reach the bottom of the groove as shown in Fig. 94.

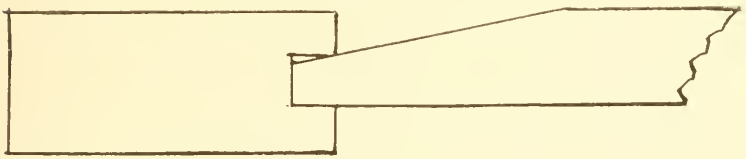


Fig. 94.

Next put the frame together, enclosing the panel. Clamp the frame together and wedge the tenons at their ends and cut off the ends of the tenons even with the outside of frame. Dress off the ends of side pieces of frame and the work is complete.

By performing the exercises shown in the foregoing pages the student should acquire sufficient skill in the use of bench tools, to enable him to leave this class of practice and begin on another line.

PART TWO.

Wood Turning for Beginners.

The first to be considered is the lathe together with a description of its principal parts, the shears, the head-stock, the tail-stock and the tool-rest.

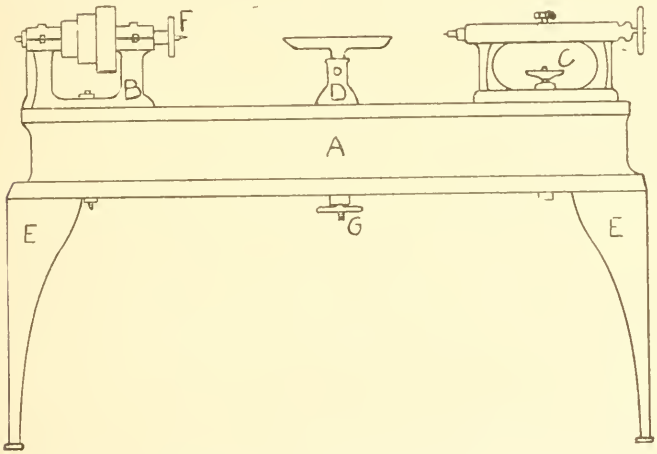


Fig. 95.

The shears or bed are supported by legs to give the shears the proper height. (See E, Fig. 95.) The office of the shears is to support the head-stock, tail-stock, and tool-rest. The headstock is in a fixed position on the shears. The tail-stock is movable and may be fixed at any position along the shears to accommodate the work to be done. The tool-rest may be adjusted to any position along the line of the shears, between the head-stock and tail-stock, and in any direction to accommodate the work to be done. The head-stock (see B, Fig. 95) carries the spindle, and the spindle is provided with a cone-pulley, which carries a belt, which drives the spindle. The

spindle also carries a forked driving-center which revolves the piece of work in the lathe. The face-plate F is screwed on the end of the spindle and is for the purpose of attaching work which is thin and has no great length, to the lathe. The tail-stock C is to support the other end of the work, and upon the cup-center held in the tail-stock the work revolves. The rest D is adjustable at any point between the head-stock and tail-stock, as the work may require, and is held in position by means of screw-clamps or eccentrics at the bottom of the shears. (See G, Fig. 95.) The rest is required to support the tool and to assist in guiding it in a proper manner. The forked or driving-center is shown in Fig. 96. The cup-

Fig. 96.

Fig. 97.

center is shown in Fig 97. The face-plate is shown in Figs.

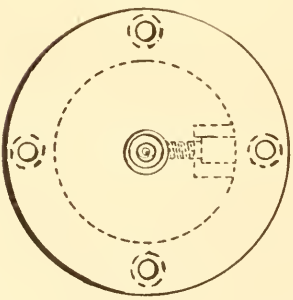


Fig. 98.

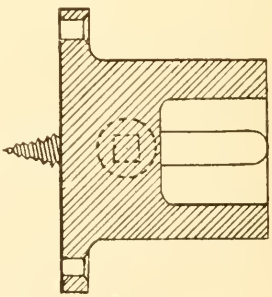


Fig. 99.

98 and 99. A larger face-plate is shown in Fig. 100. The swing of the wood-lathe is determined by measuring the distance from the point of the driving-center of the spindle

to the shears or bed, and multiplying by two. Thus, if the distance from the center of spindle to the bed is 6 inches or

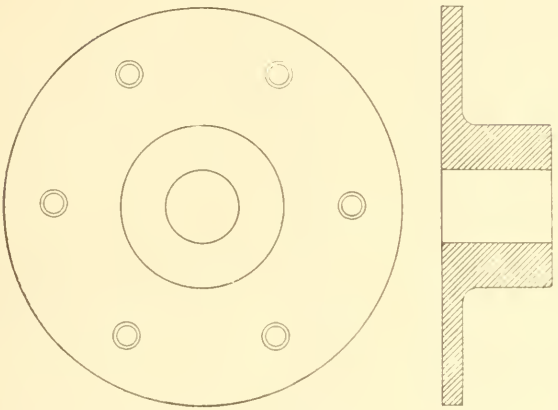


Fig. 100.

more, the lathe will accommodate work 12 inches in diameter. The lathe tools are next considered.

The gouge, (See Fig. 102) possesses the widest range of usefulness to the wood-turner and is first used to remove the rough corners of the piece. The same tool may be advantageously used in cutting grooves and compound curves. In the hands of a skillfull workman this tool may be made to do the work of other tools. The skew or finishing-chisel is shown in Fig. 103, and is used for finishing cylinders and cones, also for cutting convex surfaces, such as beads, balls, etc. It is also useful in cutting or squaring the ends.

The scraping tools, such as are shown in Fig. 104, are used principally on face-plate work where the gouge or skew-chisel would be dangerous The scraping-tools are ground and whetted only on one side and when the whetting has been done, no effort should be made to remove the feather or wire edge, as this is a benefit to a scraping-tool. A scraping-tool of great merit is shown in Fig. 105. The tool is ground and whetted on one side only, as all other scraping-tools are, but its peculiar feature is corrugations on its upper side. When properly

ground and whetted it has teeth on its cutting edge. This tool is useful in face-plate work, when the diameter of the work is great and the vibrations of the lathe and face-plate are de-

Fig. 102.

Fig. 103.

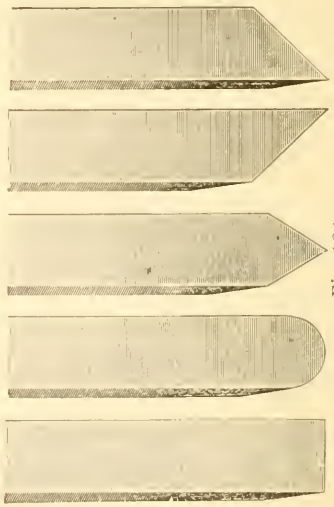


Fig. 104.

trimental to smooth surfaces. This tool may be used successfully when the vibrations are so great that no other tool could

be used. It makes a smooth surface, or so nearly so that sand paper will correct all irregularities. Add to the tools already mentioned the outside and inside calipers, the rule for measur-

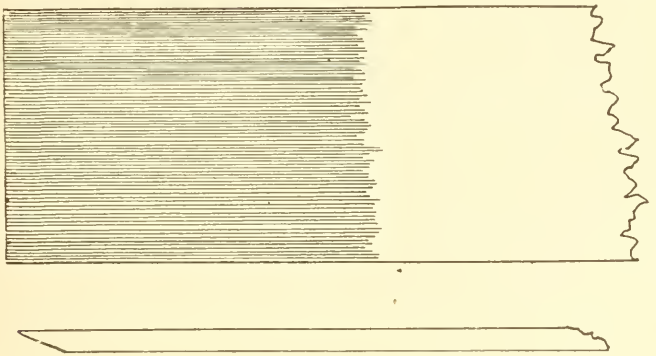


Fig. 105.

ing, the compasses for scribing, and the list of lathe-tools is complete for almost any work which the wood-turner may come in contact with. In some cases, however, such as grooves and over-hanging portions, which cannot be reached with an ordinary tool, special tools are necessary to accomplish the work to be done. Special tools are necessary, for instance, in turning a ball within a hollow ball.

EXERCISE NO. 1.

Exercise No. 1 in wood-turning is shown in Fig. 106 and consists of a parallel cylinder 6 inches in length and 1½ inches in diameter. The stock for this exercise

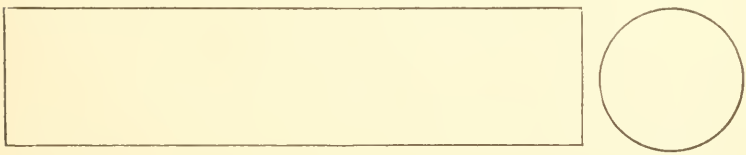


Fig. 106.

should by 1⅝ inches by 1⅝ inches by 7 inches. The

center of the ends may be found in the manner shown in Fig. 107. Draw diagonal lines on each end, and the Intersection of these lines will be the center of the piece. At this point place the points of the lathe-centers and adjust, so that the work will revolve easily. Tighten the binding screw on the tail-stock spindle and the work is ready to be turned. With the gouge take off the rough corners of the piece in short cuts, moving the tool toward the starting end of the work. (See Fig. 108.) Never move the tool in a direction toward the uncut or square corners. This is to prevent splitting off the square corners and causing great danger to the operator. After the corners have been removed with the gouge and the piece is near the required size, the skew-chisel is used in finishing to

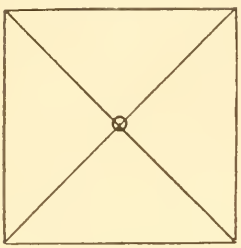


Fig. 107.

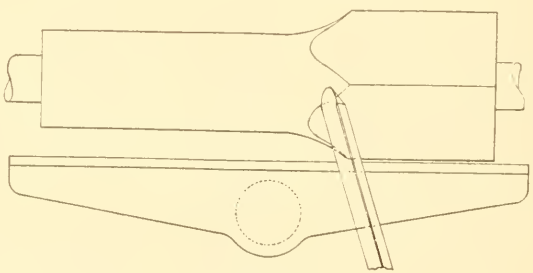


Fig. 108.

the correct size. Place the chisel on the work as shown in Fig. 109 and cut only with its heel, the cutting edge being at an angle of about 45 degrees with the line of the lathe-centers. Finish each end in this manner. Test diameter with the calipers. After the ends are reduced to the desired diameter, straighten from end to end with the skew-chisel. Test the diameter at the center with the calipers or a straight edge reaching from end to end of the cylinder. Square one end with the point of the skew-chisel, cutting at right angles to

lathe-centers. (See Fig. 110.) Mark off the length the cylinder is to have, measuring from the finished end. Mark and

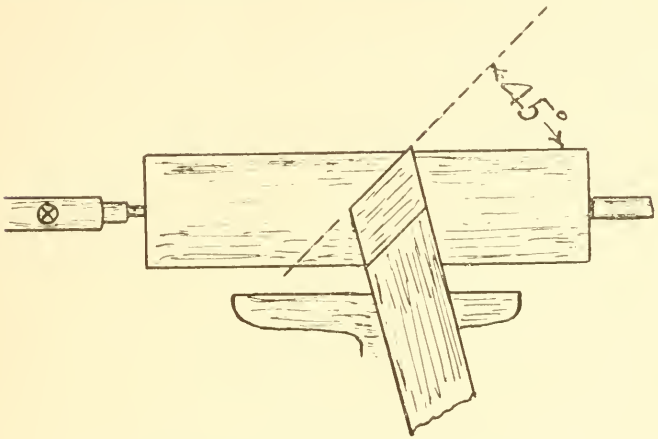


Fig. 109.

cut off to the line, leaving only a small portion to be cut off with the saw after the piece has been removed from the lathe.

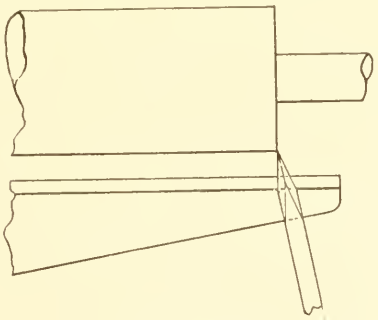


Fig. 110.

EXERCISE NO. 2.

Exercise No. 2 consists of a conical shaped piece 6 inches in length and having a diameter at one end of 1½ inches and at the other end ¾ inch. (See Fig. 111.) Material of

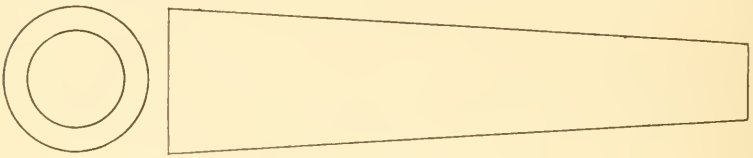


Fig. 111.

the same dimensions as in Exercise No. 1 is needed. Place in the lathe in the same manner and remove the square corners with the gouge. Next square one end with the point of the skew-chisel and measure off the length, making a deep cut line at this end. With the skew-chisel reduce this end to 1¼ inches. Next, with the gouge, reduce the squared end to nearly ¾ inch, and finish to correct dimensions with the skew-chisel. With the correct diameter at each end nothing more is to be removed from the ends. Straighten from end to end with the skew-chisel, testing with the straight edge. Remove the work from the lathe and saw off the ends and the work is complete.

EXERCISE NO. 3.

Exercise No. 3 is shown in Fig. 112. The length is to be 6 inches and the diameter at the ends and the center is 1½

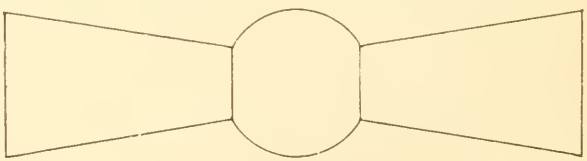


Fig. 112.

inches. The diameter next to the ball is to be ¾ inch. The same size of material is necessary as in Exercises Nos. 1 and

2. Place the piece in the lathe as before described. Rough off with the gouge, and reduce to 1½ inches with the skew-chisel. Measure and mark off the length, 6 inches, as in Exercises 1 and 2. Set the points of the compasses at 2¼ inches and with one point of the compasses at end line of piece, and the other point reaching toward the opposite end, the compasses resting across the tool-rest, the joint raised slightly above the points, scribe a line from each end. With the point of the skew-chisel make incisions at the two lines as shown in Fig. 113 to a depth of ⅜ inch. With the skew-chisel cut the

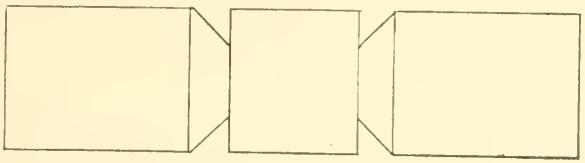


Fig. 113.

tapers from each end toward the center. To turn the ball the work must be done with the skew-chisel, cutting only with the extreme heel, and holding the tool-handle back of an imaginary line running at right angle to the centers of the lathe, the handle being always kept on the opposite side of the line from the direction in which the cutting edge is being moved. This is important, and must be observed or the operator will be unable to prevent the tool catching and badly marring the surface of the work. When one side is finished the chisel must be reversed and the other portion of the ball will be cut, the cutting being done from the center line. The diameter of the ball may be tested with the calipers. Next, remove the work from the lathe and cut off ends with the saw, and the work is complete.

EXERCISE NO. 4.

Exercise No. 4 is shown in Fig. 114, and consists of eight beads, having a pitch of ¾ inch. This exercise is of the same dimensions as the preceding one as far as length and diameter

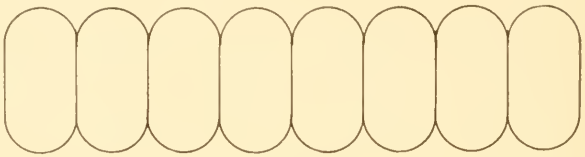


Fig. 114.

are concerned, that is, 6 inches by 1½ inches. Proceed with the work as in Exercise No. 1 until a parallel cylinder is produced. Then with the compasses set at ¾ inch place one point at one end of the cylinder, the other point extending toward the other end, and the compasses resting across the tool-rest. Mark a line ¾ inch from the end. Next place the first point of the compasses at the line made, the other point extending in the same direction as before, scribe another line, as shown in Fig. 115. Continue this operation until the end of the stick

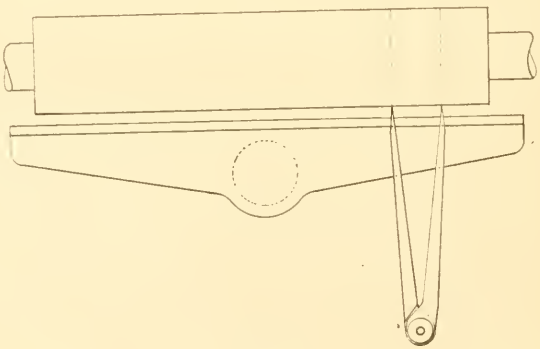


Fig. 115.

has been reached. After the lines are scribed around the piece ¾ inch apart, the skew-chisel point is next used to make

incisions at the lines drawn, as shown in Fig. 116. Cut these V shaped incisions ⅜ inch deep and round up with the heel

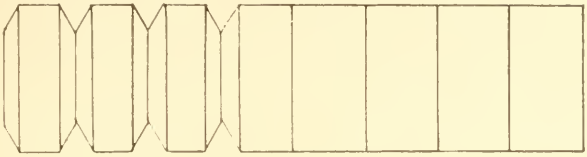


Fig. 116.

of the skew-chisel, observing the rule as laid down in Exercise No. 3 for cutting balls or beads.

EXERCISE NO. 5.

Exercise No. 5 is a series of grooves cut in a parallel cylinder as shown in Fig. 117. The spaces at the ends and between the grooves are ½ inch wide, and the grooves are ¾

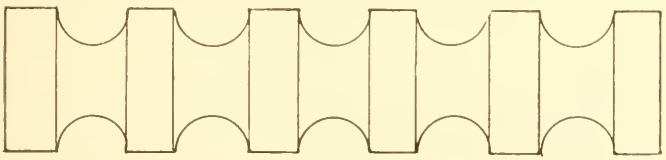


Fig. 117.

inch wide and ⅜ inch deep. The material for this exercise should be about 8 inches by 1⅝ inches by 1⅝ inches. First turn a parallel cylinder 1½ inches in diameter and 6¾ inches long. Set the compasses at 1¼ inches and with one point at either end mark off lines at intervals of 1¼ inches across the piece. Then beginning at the opposite end mark off lines in the same manner from this end. These lines will form the outlines of the grooves and spaces. Then with the ½ inch gouge, begin in the manner shown in Fig. 118. When cutting the left-hand half of grooves start with the gouge in the position shown at A, and when starting to cut the other half have the gouge as shown at B, never cutting more than half the groove in one motion. When the grooves have been

formed their depth may be tested with the calipers. The diameter at the bottom of the grooves should be ¾ inch.

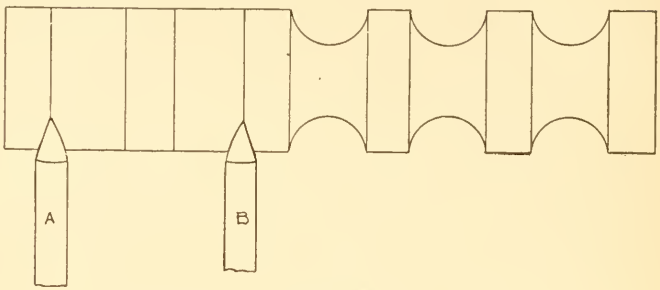


Fig. 118.

When this diameter has been acquired and the curves are cut to the lines scribed, and are symmetrical, the piece is ready to be removed from the lathe.

EXERCISE NO. 6.

Exercise No. 6 consists of a number of beads, cut on a parallel cylinder as shown in Fig. 119. The same size of material is to be used as in Exercise No. 1. First, cut off the

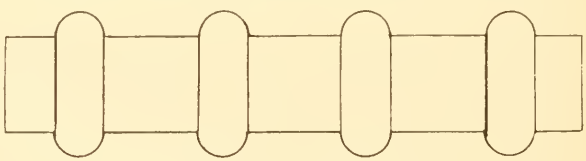


Fig. 119.

square corners of the piece with the gouge and reduce to 1½ inches diameter with the skew-chisel. Square one end and mark and cut the length 6 inches. With the compasses mark off the beads and distances between, as shown in Fig. 119. With the point of the skew-chisel, make incisions ¼ inch deep as shown in Fig. 120. With the small gouge cut out the material between the beads and with small skew-chisel

smooth and reduce to 1 inch diameter. With the calipers test the diameter between the beads. With the small skew-chisel round up the beads as in Exercise No. 4, always keeping

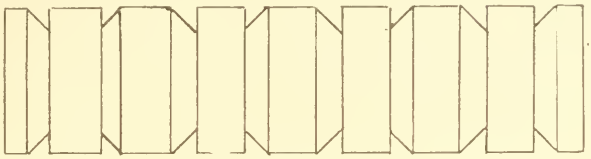


Fig. 120.

in mind the rules laid down in Exercise No. 3. When the beads are finished the piece may be removed from the lathe and the ends sawed off. The piece is now finished.

EXERCISE NO. 7.

Exercise No. 7 is shown in Fig. 121. The same size of material is necessary in this as in Exercise No. 1, and the work is begun in the same manner. First produce a parallel cylinder

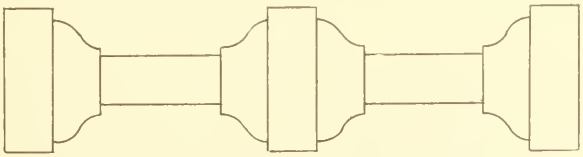


Fig. 121

1½ inches in diameter by 6 inches in length. With the compasses set to ½ inch, scribe a line that distance from each end, and another one 1 inch from each end. Re-set the compasses at 2¼ inches and scribe a line from each end. Re-set again at 2¾ inches and scribe a line from each end. When this has been done the work will appear as in Fig. 122. With

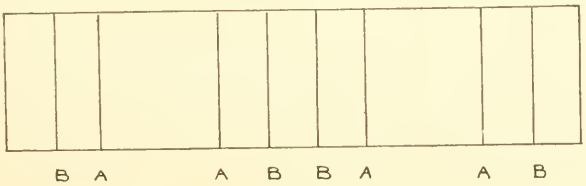


Fig. 122.

the ½ inch skew-chisel make an incision ½ inch deep at A. Cut away the material between the lines A and A with the small gouge, finishing with the ½ inch skew-chisel to ½ inch diameter as shown in Fig. 123. With the skew-chisel reduce

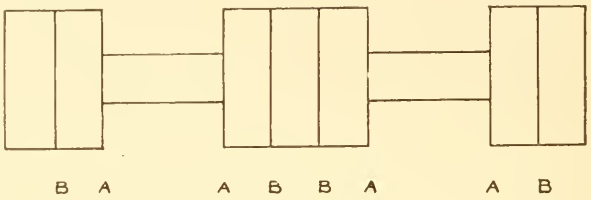


Fig. 123.

the diameter ⅛ inch between the lines A and B as shown in Fig. 124. With the ½ inch gouge form the curves as shown

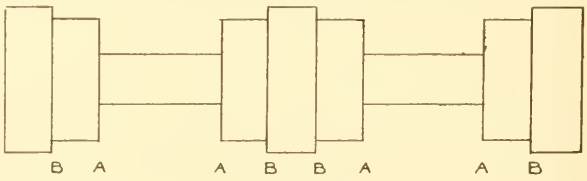


Fig. 124.

in Figs. 125 and 126. When this has been done the work is complete. When the student has become proficient, and can

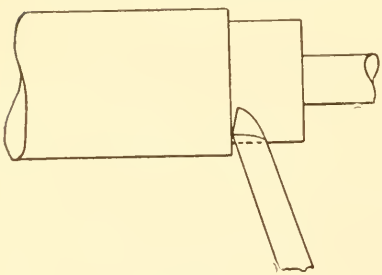


Fig. 125.

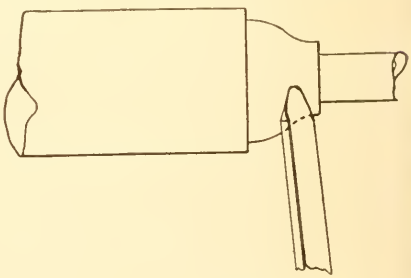


Fig. 126.

perform the work well in the foregoing exercises with the tools intended to be used for such work he will be able to work out more difficult ones as occasion may require.

EXERCISE NO. 8.

Exercise No. 8 consists of a handle for a paring-chisel or a lathe-chisel, and is shown in Fig. 127. The material for this should be hard wood and of the length and size to ac-

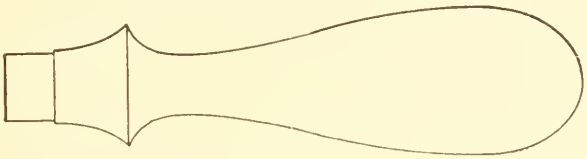


Fig. 127.

commodate the work to be done. Place the piece in the lathe as in the preceding exercises, and with the gouge reduce the piece to the diameter of the largest portion of the handle to be made. With the skew-chisel mark a line at a distance from the end equal to the length of the ferule to be put on. With the heel of the skew-chisel reduce the portion between the end and the line drawn to the proper diameter for the ferule. The piece may then be removed from the lathe, and the ferule placed in its position, and the work returned to the lathe. With the gouge form the fillets; form the convex curves with the heel of the skew-chisel. This piece of work should now be smoothed with sand paper, and polished either with linseed-oil or shellac varnish. Remove from the lathe and cut off the end.

EXERCISE NO. 9.

Exercise No. 9 is shown in Fig. 128, and must be made on the face-plate. The tools to be used are the scraping-tools.

Fig. 128.

Material for this exercise should be 4½ inches square and 1

inch thick. Dress one side with the plane and scribe a circle with the compasses on the dressed side 4¼ inches in diameter. Saw to the circle on the band-saw. Fasten the disc to the face-plate with the center-screw, with the dressed side against the face-plate. With the round-nose chisel remove the rough

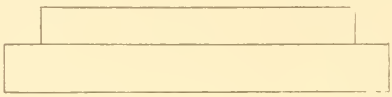


Fig. 129.

edge of the disc and finish with square edge scraping-chisel to 4 inches diameter. With the same tool finish the flat surface, reducing the thickness to ⅞ inch. With the same tool

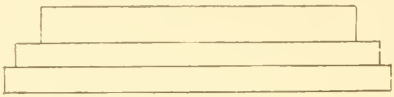


Fig. 130.

remove the corner to a depth of ⅜ inch from the face, reducing the face to a diameter of 2¾ inches, as shown in Fig. 129. With the same tool cut from the edge toward the center

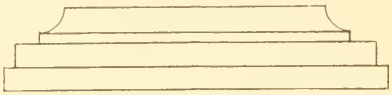


Fig. 131.

of the disc, leaving only ¼ inch of the width of the edge and cutting to a depth of ⅛ inch, as shown in Fig. 130. With the round-nose scraping-tool form the concave curve as shown

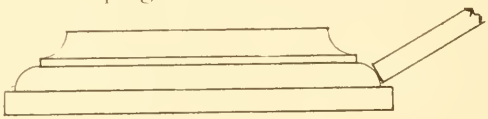


Fig. 132.

in Fig. 131. Finally, with the narrow square edge scraping-tool round the corner to form a quarter-round bead, as shown in Fig. 132.

EXERCISE NO. 10.

Exercise No. 10 is a small picture frame, a cross section of which is shown in Fig. 133. The material for this exercise should be 7 inches by 7 inches by 1 inch. To prepare it for

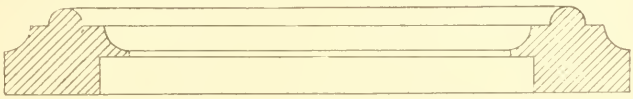


Fig. 133.

the lathe proceed in the same manner as in the preceding exercise, except that it is unnecessary to dress with the plane. Scribe a circle on one rough side 6¾ inches in diameter and saw to the circle with band-saw. Attach to the face-plate by the center-screw and reduce the edge of disc with the scraping-tools until a diameter of 6½ inches is obtained. With the square edge tool face off the flat side and cut with the same tool to the shape shown in Fig. 134. The opening shown

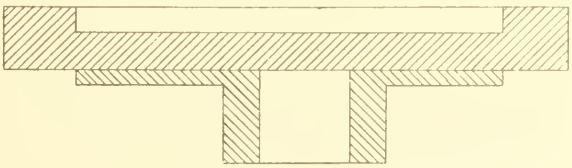


Fig. 134.

in Fig. 134 is to be 4½ inches across with a depth of ¼ inch. After this cut has been made, remove the piece from the face-plate and attach to the center-screw another disc, one having a diameter greater than 4½ inches. Face this off with the square edge tool, and reduce the diameter to 4½ inches. Place the piece on this disc in the manner shown in Fig. 135.

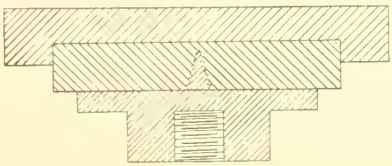


Fig. 135.

A good fit is necessary to retain the price in its proper position until the work is finished. Next reduce the piece to a thickness of 7/8 inch. This is to be done with the square edge scraping-tool. With the diamond-point or side-tool remove the center of disc as is shown in Fig. 136.

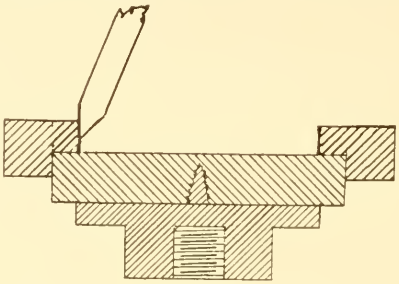


Fig. 136.

The opening should be 3¾ inches across, and the width of material remaining, 1⅜ inches. Next, with the square edge chisel, cut away the corners to a depth of ¼ inch from the face and 7-16 inch from both inside and outside edges. Then the piece will appear as in Fig. 137, a portion ½ inch in width and ¼ inch in height remaining at the center of face. This projecting portion may now be rounded up with the square edge chisel, as shown in Fig. 138, which forms a bead. After

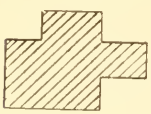


Fig. 137.

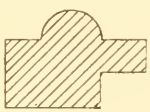


Fig. 138.

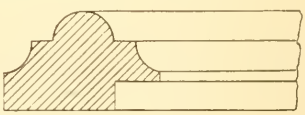


Fig. 139.

this the concave curves may be cut with the round-nose chisel, leaving a margin of ⅛ inch on either side of the bead and cutting to depth of ¼ inch in a direction toward the face-plate. A section of the work will then appear as in Fig. 139. The piece may now be smoothed with sand-paper and polished with oil or shellac, and the frame is complete.

EXERCISE NO. 11.

Exercise No. 11 is shown in Fig. 140. The stock for this exercise should be 4 inches by 4 inches by 6 inches. Attach

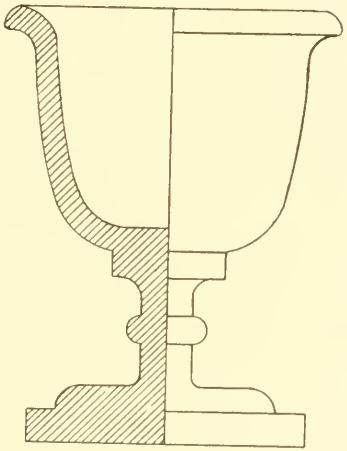


Fig. 140.

to face-plate endwise by center-screw and true up with gouge and skew-chisel to the diameter of the largest portion of the exercise which is 3½ inches. With the point of the skew-

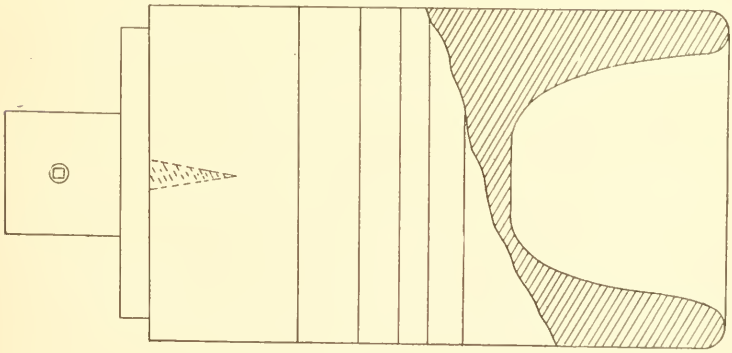


Fig. 141.

chisel, square the end. Proceed with the round-nose chisel to cut out the inside of cup as shown in Fig. 141. After the inside

of cup has been finished, and polished with the oil or shellac, the lines marking the distances from bottom to top are to be measured, and marked with the compasses. Next, with the point of skew-chisel and small gouge, remove the portion as

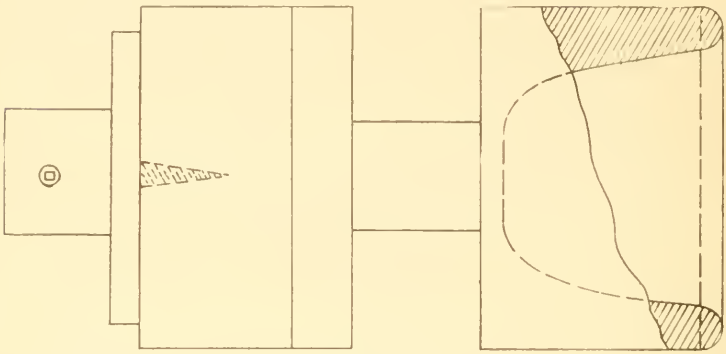


Fig. 142.

shown in Fig. 142. The portion outside of dotted lines may be cut away with the gouge and square edge scraping-tool. When this has been done the piece will appear as in Fig. 143.

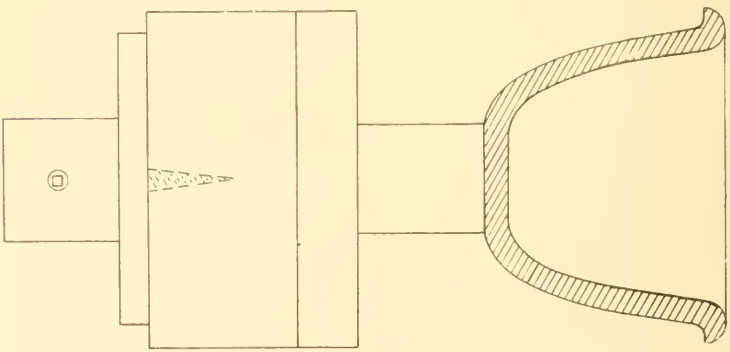


Fig. 143.

The stem may next be formed with the gouge, the round-nose and diamond-point scraping-chisels. The exercise will then

appear as in Fig. 144. The base is the only portion remaining to be formed. The cutting off at the bottom line is done with the point of the skew-chisel. The edge of the bottom is

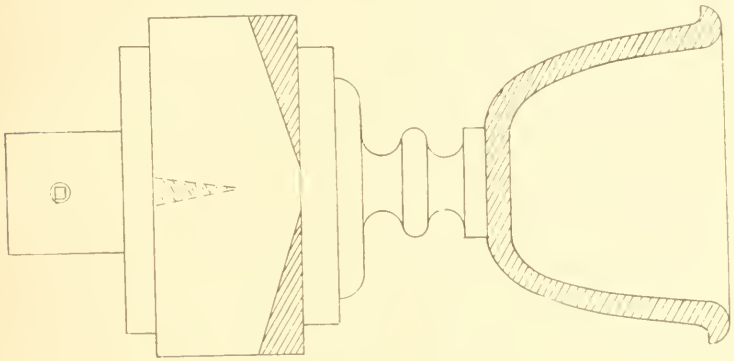


Fig. 144.

smoothed with the square edge scraping-tool. Sandpaper and polish the outside, and the work is ready to be removed from the lathe.

EXERCISE NO. 12.

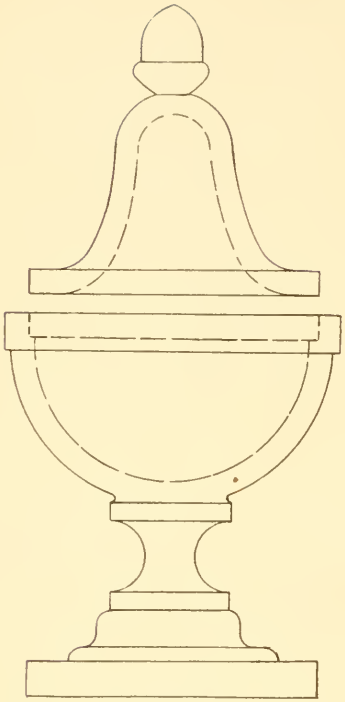


Fig. 145.

Exercise No. 12 is shown in Fig. 145, and is a cup or urn similar to Exercise No. 11, except that the angles and curves are slightly different and the urn has a cover. Two pieces are necessary to complete this exercise. For the cup the same size material is used as in Exercise No. 11, and is attached to the face-plate in the same manner. Begin turning by roughening off with the gouge and finishing to $3\frac{1}{2}$ inches diameter with the skew-chisel. Next square the end with the point of the skew-chisel, and turn out the inside of cup with the round-nose chisel to a diameter of $2\frac{7}{8}$ inches. When this is done cut the seat for the cover with the square-end scraping-

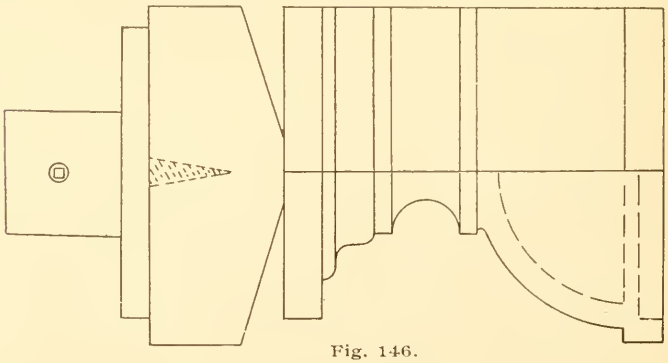


Fig. 146.

tool, when the piece will appear as in Fig. 146. Next mark off the lines from the top to the bottom of the cup as shown in Fig. 146.

With the point of skew-chisel, make incisions as shown in Fig. 147, and reduce the size of piece at this point to 1¼

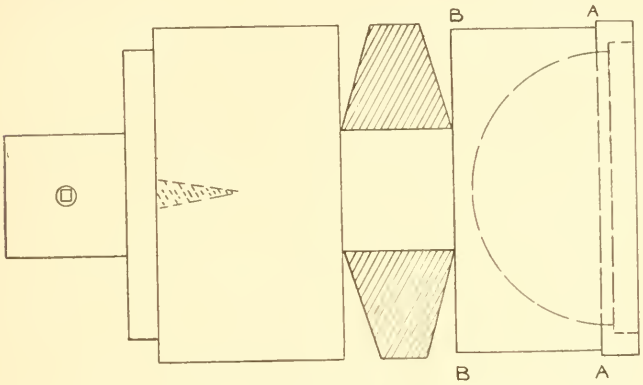


Fig. 147.

inches. With the point of skew-chisel, next make an incision 1-16 inch in depth, as shown at A, Fig. 147, and reduce diameter of body of cup to 3⅜ inches as at B. With the heel of

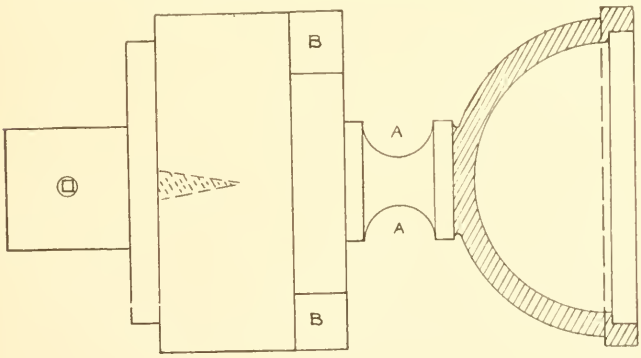


Fig. 148.

skew-chisel, next form the curve of outside of bowl, as shown in Fig. 148. With the small gouge, next cut fillet in the stem,

as at A, Fig. 148. With the skew-chisel, remove the portion marked B, leaving the diameter 2¼ inches. With the small gouge, next form the compound curves in the stem, below the fillet, when the piece will appear as in Fig 149. With

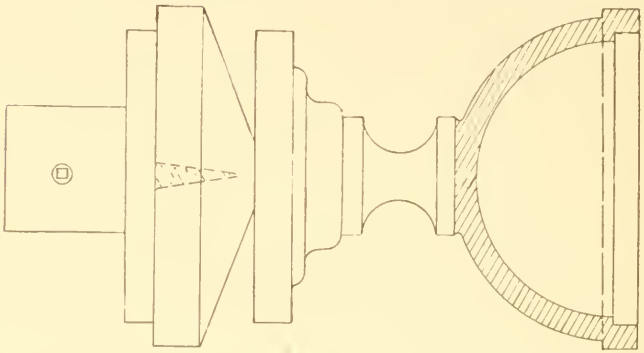


Fig. 149.

the point of the chisel, next make an incision at the last line, and with the square edge scraping-tool, reduce the diameter of the base to 3 inches. Next sandpaper and polish. The work is then to be cut off at the bottom with the point of skew chisel, and this piece of the exercise is complete.

The other portion of the exercise is the cover, and requires

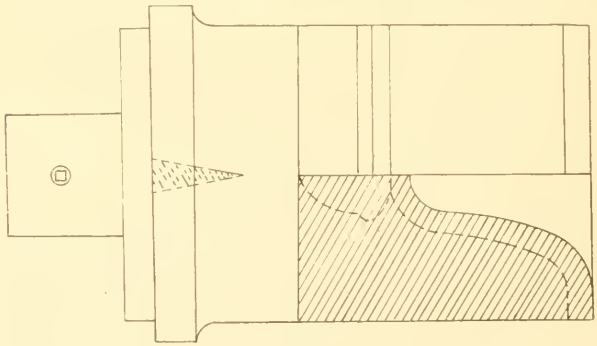


Fig. 150.

material 4 inches by 4 inches by 6 inches. This piece is to be attached to the face-plate in the same manner as the pre-

ceding half and the corners reduced to 3 1-16 inches with the gouge and skew chisel. Square the end with the point of skew chisel and proceed with the round-nose chisel to remove the inside portion of cover as shown in Fig. 150. With the point of skew chisel, next mark a line ¼ inch from the end. Mark another line at the terminus of compound curves

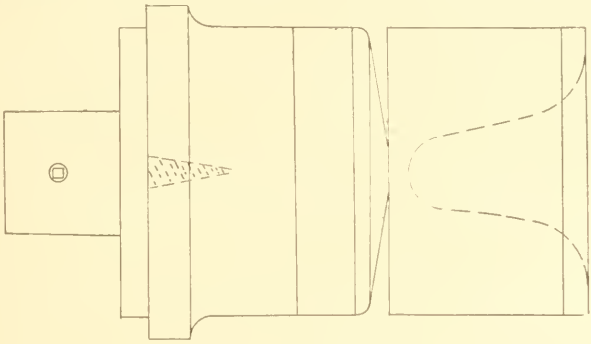


Fig. 151.

of the outside of cover, and others for the acorn or handle on top of cover. With the point of skew chisel make incision at the second line as shown in Fig. 151. With the gouge next form the curves of the outside of cover, when the work will

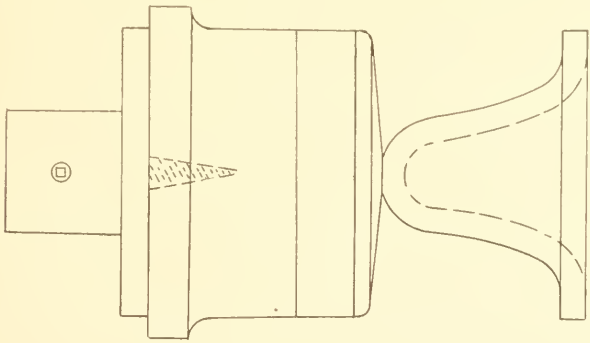


Fig. 152.

appear as in Fig. 152. The next step is to sandpaper and polish the cover as it will be too frail and not rigid enough

to stand the pressure of polishing after the acorn has been formed. After the polishing, form the acorn or handle with the small skew chisel and gouge, leaving a small stem not cut off to retain the work on the face-plate until the acorn or handle of cover can be sandpapered and polished. After this, cut off the stem and the work of this exercise is complete.

The foregoing exercises in wood-turning will be sufficient to demonstrate the use of all the principal tools in wood-turning and to prepare the student for any exercise he may be given in pattern work.

THIRD PART.

PATTERN MAKING.

Of the different kinds of wood serviceable to the pattern maker soft white pine is for many reasons the best. It should be of the best quality, straight grained and free from knots. It is then easy to work in any direction, and possesses at the same time sufficient strength for all but the most delicate kinds of work, and has, besides, the quality of cheapness to recommend it. Care taken in its selection at the lumber yard will be amply repaid in the pattern shop. When it is straight grained the marks left by the saw will show an even roughness throughout the whole length of the plank and the rougher the appearance the softer and better for the purpose of the pattern maker. That which saws comparatively smooth will be found hard and troublesome to work. If the plank has an uneven appearance, rough in some places and smooth in others, the grain is crooked, and, in planing it, the grain tears up and a smooth surface cannot be obtained.

The superiority of pine for pattern making, however, is not maintained when we come to fine and delicate patterns or those requiring great durability. When patterns are required for fine work, from which a great many castings are to be made, a pattern wherefrom to cast an iron pattern must be made. If pine were employed, it would not only wear out rapidly, but would soon warp and become useless.

It is true that a pine pattern will straighten more easily than one made of hard wood, but its sphere of usefulness in fine patterns is, for the above reasons, somewhat limited. Iron patterns are very desirable on account of their durability and because they leave the sand easily and cleanly, and because they do not warp. They are also less liable than the wooden

ones to give way to the sand, while the latter is being rammed around them, by the moulder, a defect that is often experienced with light patterns, especially if they are made of pine. Iron patterns, however, are expensive, and therefore it is that mahogany is extensively used for fine or durable pattern work.

Other woods are sometimes employed, because they stand the rough usage of the foundry better and retain the sharp corners better than the pine. In case pine is used, the corners become rounded in time, and impair the appearance of the casting. Mahogany is not liable to warp nor subject to decay, and is for these reasons the most desirable of all woods for pattern making. There are various kinds of mahogany, but that known as "South American" is most used for patterns. Next to mahogany we may rank cherry, which is a very durable wood, but more liable to twist or warp than mahogany and is somewhat harsh to the tool's edge. If, however, it is stored and well seasoned before being used, reliable patterns may be made from it. Small patterns and core boxes, however, may be made successfully from hard maple

The one property in all timber to be specially guarded against is this tendency to warp, bend, expand and contract, according to the amount of humidity in the atmosphere. Under ordinary circumstances, we shall be right in supposing moisture to be given off constantly from all exposed surfaces of timber. Therefore, lumber stored in the pattern shop should be placed in a rack, so contrived that the planks do not touch one another, so that the air can circulate between the planks and dry all surfaces as nearly alike as possible. If a plank newly planed be lying on the bench, on its flat side, the moisture will be given off freely from the upper surface, but on the under surface will be confined between the bench and the plank. The result will be that the plank planed straight and left lying as described will be found, even in an hour, to be curved, from the contraction of the upper surface, due to the extra expos-

ure. See Fig. 153. Therefore it is that lumber newly planed should be stored on end or placed on its edge. Lumber expands and contracts with considerable force across the grain.

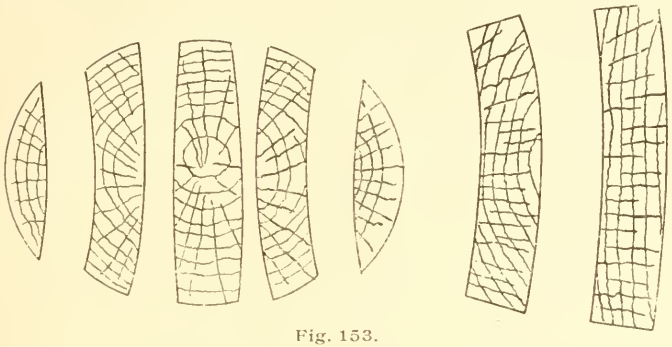


Fig. 153.

Hence, if a piece, even of dry plank, be rigidly held and confined at the edges, it will shrink and rend in twain, often with a loud report. There is no appreciable alteration lengthwise from the above causes. If two pieces are glued together in such a manner that the grain of one crosses that of the other, they can never be relied upon to hold safely.

The shrinkage, expansion, and warping of timber may perhaps be better understood by considering as follows. The pores of the wood run lengthwise or with the grain, and hence, the moisture contained in these pores passes off more readily endwise or from any surface on which the pores terminate. Then again, the wood shrinks precisely in the proportion in which the moisture leaves it, and, if we have full knowledge of the direction of the grain, and of the position in which a piece of timber stands or lies, we can predict in which direction it will warp. Thoroughly seasoning the timber will not remove its tendency to warp. For no matter how long and carefully timber has been dried or seasoned, it undergoes considerable transformation of shape, as soon as much of its surface has been removed, making it appear that the seasoning or drying process takes place mainly at the outer surfaces. If we take a thoroughly seasoned piece of wood three inches

square and one foot long, and cut it into strips one inch square, the pieces will warp, and after a time if we take these one inch strips and cut them into strips ¼ of an inch square, these will again warp; and no matter what pains may be taken with these last strips to season them and let them assume their new shape, if we cut them into thin veneers, the warping process would again set in. It is well, therefore, in particular work, to cut out roughly the various parts of the pattern, so that while some parts are being worked upon, the others may be assuming their new shape and become less liable to warp after being worked up in the pattern.

There are some essential rules, which must be known to the student, before he begins work on the pattern. Namely, those regarding draft, shrinkage and allowance for finish, as well as for shellacking and finishing.

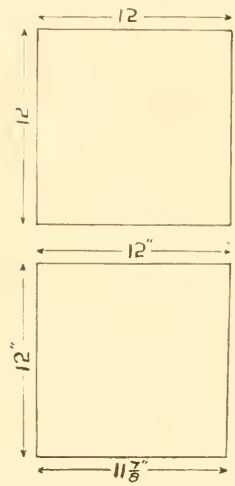


Fig. 154.

By draft in pattern practice is meant the allowance the pattern maker makes for the assistance of the moulder, to enable him to remove the pattern after it has been rammed up in the sand. Fig. 154 will give an idea of what is meant by draft. This figure represents a cube 12 inches square to be made of iron. The dimensions of the pattern must be ⅛ inch less at the bottom than at the top. In this case the bottom would be 11⅞ inches and furnish a draft of ⅛ inch in twelve. This allowance should be made on the vertical sides of all patterns, for otherwise, the moulder would experience trouble in removing the pattern from the sand after having molded it.

Allowance for shrinkage means that the pattern must be made as much larger in every direction as the metal will shrink in cooling after the casting is made, thereby leaving the casting true to the dimensions given in the drawing. This allowance in ordinary cast iron is ⅛ inch in 12 inches. This is made easy for the pattern maker by the use of the shrinkage rule. This rule is 24¼ inches long, standard measure, and is divided in the same manner as the standard rule into inches and subdivisions of an inch. Patterns for brass castings require an allowange of 3-16 inch in 12 inches.

Rules for shellacking and finishing are as follows: A pattern to be cast in iron should be varnished black and the core prints yellow. For brass the pattern should be yellow, and the core prints black. In applying the varnish to the pattern, personal instruction is deemed necessary. Allowance for finish of the casting must be made in accordance with drawings and specifications. Ordinarily the allowance for finish in iron is ⅛ inch on each surface, where finish is required, and 1-16 inch on brass castings.

EXERCISE NO. 1.

Exercise No. 1 in pattern making is a hand face-plate and is shown in Fig. 155. Add ⅛ inch to the thickness of the plate to allow for finish of the casting at F. Plane out the plate

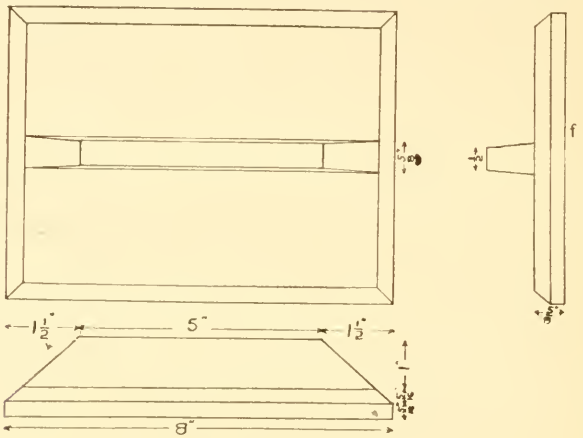


Fig. 155.

to the required thickness and give the edges a draft toward the handle of plate. Dress out the handle to the required size, giving it draft on its sides. Glue and nail handle to plate. With a piece of sand paper folded tightly around a true surfaced block, sandpaper smoothly all surfaces of pattern, being careful to keep all surfaces and angles true and not rounding or wearing away the corners. This pattern is to be cast in iron and must be varnished black. After the first coat of varnish is dry, sandpaper all surfaces lightly until smooth, being careful not to remove the varnish with the sand paper. When smooth varnish again and repeat the above operation until a proper finish is obtained.

EXERCISE NO. 2.

Exercise No. 2 is shown in Fig. 156. The material required in this exercise should be 6½ inches by 2½ inches by 2 inches. First plane the bottom surface to a true plane and

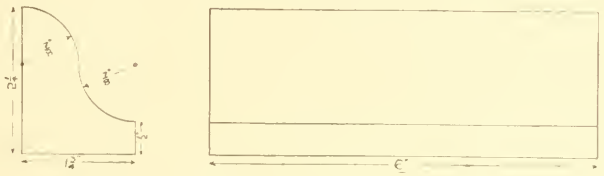


Fig. 156.

mark No. 1. Square No. 2 to No. 1. Gauge a line on surface No. 1, using No. 2 as a guide for the gauge. Plane the third side to the line made on No. 1, squaring it to No. 1. With the try square and knife mark a line around one end. Dress the end square to the line with the chisel or block plane. Next measure the length 6 inches from the squared end and mark a line around this end and dress to the line. With surface No. 1 as guide, and the gauge set at 2¼ inches, mark a line on surface No. 2. Re-set the marking gauge at ½ inch and gauge a line on surface No. 3, using surface No. 1 as a guide. Next set the compasses at ⅞ inch. Place a small block of wood against surface No. 2, and even with the surface of one end; place one point of the compasses at the terminus of the gauge line on surface No. 2, the other in the joint formed by the small block and the pattern. Using this improvised center, scribe a quarter circle on the end of piece beginning at the terminus of the gauge line. Next transfer the block to surface No. 3 and repeat the operation starting the quarter circle at the terminus of the gauge line on surface No. 3 and meeting the first quarter circle drawn, thus forming a compound curve. Repeat this operation on the other end, and the fourth surface is ready to be dressed with the gouge and chisel. Dress the concave surface to the lines with the gouge and the convex sur-

face with the chisel. Sandpaper the concave with the paper held firmly around a round sand paper block and lengthwise with the grain. The convex is to be sandpapered with the paper folded and sprung around the surface. The flat surfaces are to be sandpapered with the paper folded closely around a true and flat surfaced block, being careful not to wear away the sharp corners of the pattern. After the pattern has been shellacked and polished as in No. 1, it is ready for the moulder. Both Exercises No. 1 and No. 2 are called plain patterns for the reason that when they are moulded the mould is called a plain mould. In these cases the mould is formed in the lower portion or drag of the flask. In the following exercises the mould is formed in both the lower and upper halves of the flask and for this reason patterns are divided at the center.

EXERCISE NO. 3.

Exercise No. 3 is shown in Fig. 157 and is a hollow cylinder 2½ inches in diameter and 6 inches in length having an opening through the center 1¼ inches in diameter. The metal

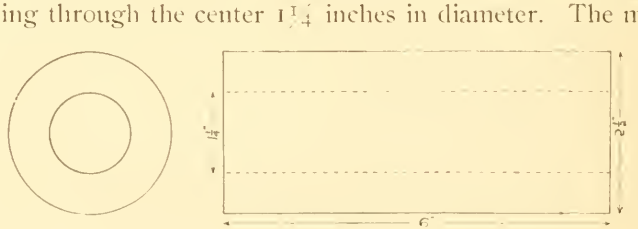


Fig. 157.

is to be ⅝ inch in thickness. To form this casting a core must be used, hence, a box in which to form the core must be made as well as the pattern. Material for this exercise must be 10 inches or more in length and 1⅜ inches by 2¾ inches. Two pieces of this size are necessary. Dress both pieces to a true plane on the widest surfaces. Place the dressed surfaces together and fasten at the ends with screws. Mark the center across piece on one side; with the auger bit bore holes through one-half of the piece and one-half inch into the

other half 2½ inches each way from the center line; place dowel pins through first half extending ⅜ inch into second half. The piece will then appear as in Fig. 158. The piece is

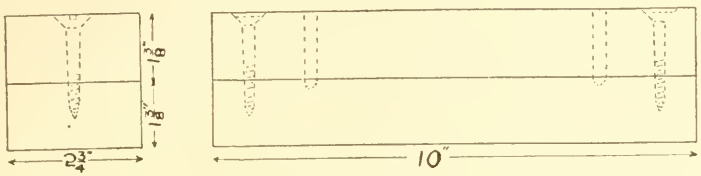


Fig. 158.

now ready to be placed in the lathe and turned to the given diameter. Mark a line at the center between the dowel pins. Measure from the center line each way with the compasses and scribe a light line to mark the end of the pattern. With the skew chisel, next make incisions at the end lines and near the screws holding the pieces together. Reduce the diameter at the ends to the inside dimensions of the cylinder, 1¼ inches, when the piece will appear as in Fig. 159. Make a

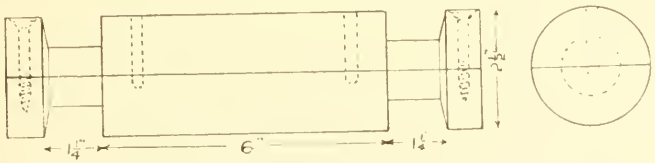


Fig. 159.

deep cut line on the 1¼ inch portions, 1¼ inches from end of the pattern. Sandpaper and smooth the piece and varnish the 1¼ inch portion yellow, and the body of the pattern black. The work of polishing patterns in the lathe may be done most neatly by using a piece of cloth on the shellac before it has dried, removing all the varnish that the cloth will remove by pressure. A very smooth finish may be obtained in this manner, but the more ordinary method is to allow the varnish to dry and then smooth with sand paper. Remove the work from the lathe and cut off the ends and varnish again, and when dry

the pattern is finished, and will appear as in Fig 160. The projecting ends 1¼ inches in diameter are called core prints and form a place in the mould in which to place the core. Ma-

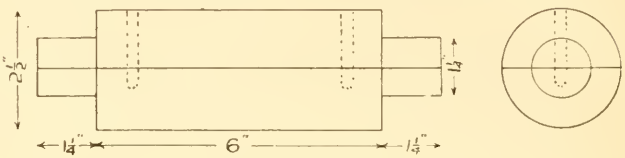


Fig. 160.

terial for the core box should be two pieces 8½ inches by 3 inches by 1¼ inches. Place the two pieces together as was done with the pattern, finished surfaces together, clamp in the vise and bore and dowel in the same manner as for the pattern except that the dowels should be near the edge. Joint one edge and square the ends, dressing end finished last until the length of the two pieces is 8½ inches, when the work will appear as in Fig. 161. Next, open the pieces, set the gauge at

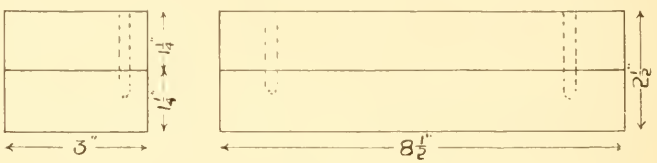


Fig. 161.

½ inch and scribe a line on the inside surfaces of both, using the jointed edges as a guide. Re-set the gauge at 1¾ inches and mark another line on each piece parallel to the jointed edge. Place the pieces together and with the compasses scribe a circle on each end between the points at which the gauge lines terminate, the points of radius being on the parting lines of the two pieces. Separate the pieces and remove the portion inside the circles and between the gauge lines with the paring gouge, allowing sufficient for sandpapering. Sandpaper with the two parts held firmly together and with the sandpaper wrapped closely around a cylindrical and parallel

sandpaper block. Sandpaper the ends until they are smooth. Varnish and polish the ends and inside of box when it will appear as in Fig. 162. The core prints on the pattern and the dotted lines in Fig. 160 represent the size of the core moulded

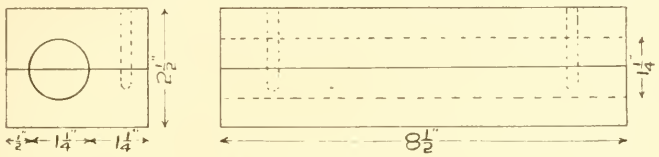


Fig. 162.

in this core box and placed in the mould after the pattern has been removed. The portion outside of dotted lines represents the space left for the metal, which, forming around the core, becomes a hollow cylinder.

EXERCISE NO. 4.

Exercise No. 4 as shown in Fig. 163 is an open end wrench. The material for this pattern should be 10 inches by 2½ inches by ⅞ inch, dressed, jointed on one edge. With the marking

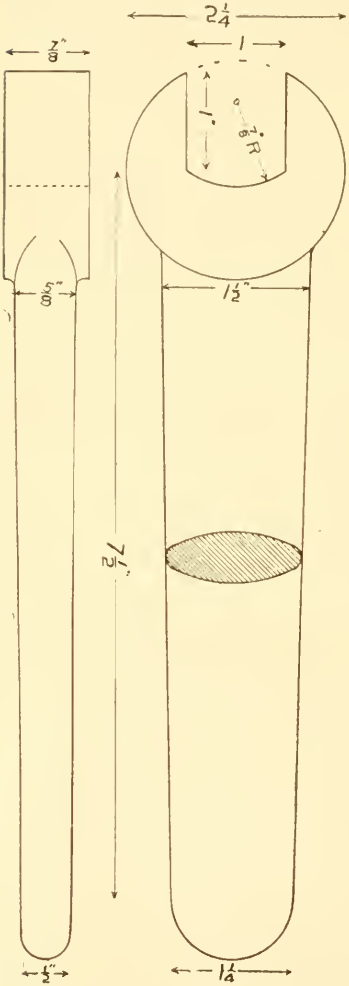


Fig. 163.

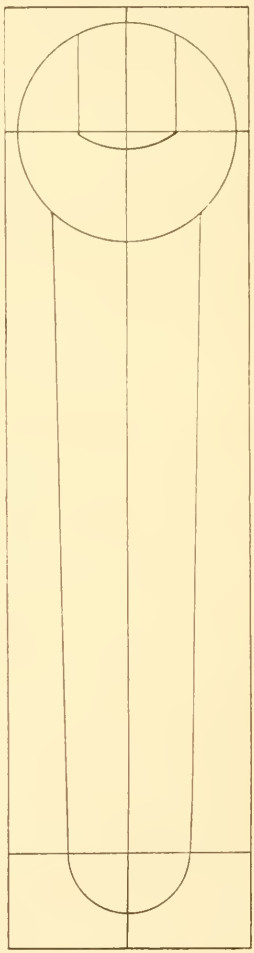


Fig. 164.

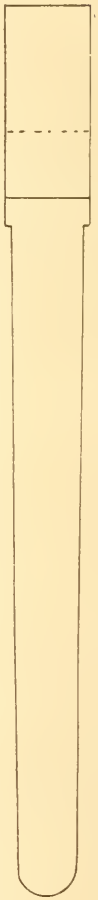


Fig. 165.

gauge, mark a line on both the wide surfaces at the center, using the jointed edge as a guide. With the knife and try square mark a line across the surface 1¼ inches from one end and continue line around on opposite side. Measure off and mark a line on opposite end 7½ inches from first cross line drawn. The points where these lines cross the center line will be the points of radius for the circle outlining the head and the end of handle. Set the compasses at 1⅛ inches and scribe a circle on both sides of one end. This is the outline of the head. Set the compasses at ⅝ inch and scribe a half circle on both sides of the other end, using the points where the lines cross as a radial point. With the compasses set at ¾ inch place one point on the center line, and, where the outline of the head crosses the center line, mark points on each side of center line. These points are to give the width at the widest portion of the handle. With a straight edge and knife mark lines from these points tangent to the half circle outlining the end of handle. Draw these lines on both sides. With the compasses set at 7-16 inch mark points on each side of center line on both sides of the head. From the jointed edge set the marking gauge at the last point marked and mark lines parallel with the center line beginning at the circumference of circle and extending to the cross lines. With the compasses set at ⅝ inch, place one point at the juncture of the last gauge line and the cross line, the other resting on the center line and between the last lines drawn. Using the latter position as a center, mark a portion of a circle from one juncture to the other, thus forming the outline of the opening in the end of the head when the lines on the piece will appear as in Fig. 164. The ¾ inch auger bit may next be used in removing the portion to be cut away between jaws, being careful to cut near the line. With the band saw next cut along the lines of the jaws. Leave enough material so that the opening may be pared to a smooth surface with the chisel and gouge. Cut to the lines on each side and afterward straighten the surfaces across. With the sand paper give the

opening a little draft. With the band saw cut near the outline and afterward pare to the line with the chisel. This properly done the outline of the wrench is formed. Next, mark point near the head on the edge of the handle ⅛ inch from the broad surfaces to designate the thickness of the handle. At the end of the handle where the cross lines terminate mark other points 3-16 inch from the broad surfaces. With a straight edge and knife mark lines from point to point the length of handle. This gives the taper of the handle. Then, with the paring chisel remove the portion outside of lines, cutting true to the lines and straightening across, leave ⅛ inch next to the outlines of the head to afterward form a fillet where the handle and head join. The piece will now appear as in Fig. 165. The handle has now the required dimensions in both outlines and must be kept so and not reduced in rounding up. The handle may be worked to an elliptical form by chamfering at the corners until a sectional view appears as in Fig. 166. When the handle has reached this stage, remove

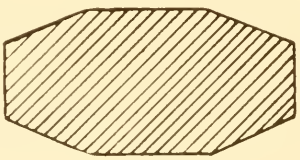


Fig. 166.

the corners or angles evenly. This will make it easy to keep the handle symmetrical in form. Form the fillet at the juncture of the head and handle with a knife or gouge. Sandpaper the handle lengthwise with the paper folded and sprung around the work. Use the sand paper on a block for flat surfaces. Preserve all sharp corners. The pattern is now ready for shellac and finishing.

EXERCISE NO. 5.

Exercise No. 5 consists of a small hand wheel as shown in Fig. 167. To construct this pattern properly the ring should be built separately and the arms inserted after the ring is

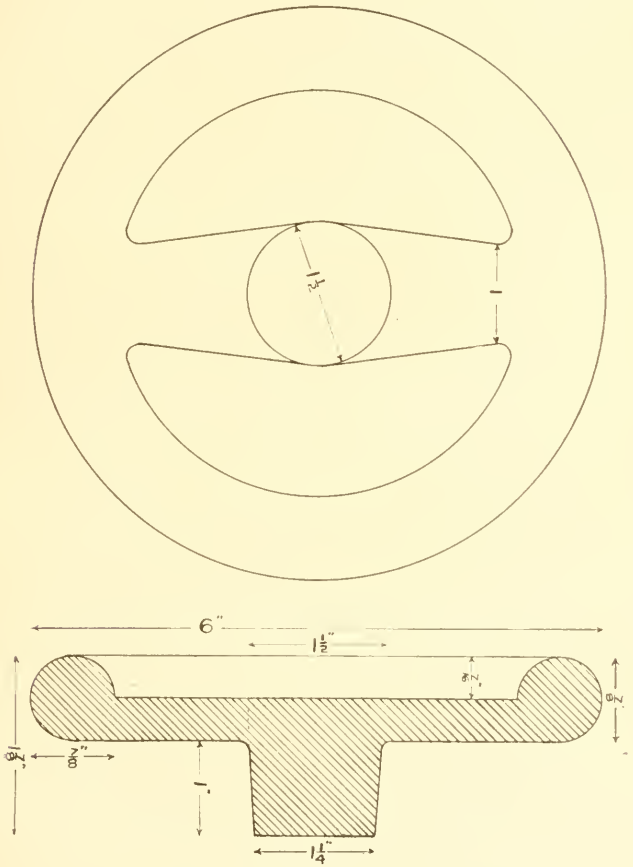


Fig. 167.

completed. The ring is 6 inches in diameter and ⅞ inch round. To construct the ring proceed in the following man-

ner: Scribe a circle on a piece of soft pine 7/8 inch thick and 6¼ inches in diameter. Saw to the circle on the band saw and attach to the small face-plate by center screw. Face up the disc in the lathe. With the compasses lay out on ¾ inch stock one-fourth of the ring, allowing stock for turning. The outside radius should be 3¼ inches and the inside radius 1⅞ inches. Saw out this segment for a pattern. Use this to mark out 7 others and saw out to the lines. Join these together endwise around the circumference of the face-plate. Glue the joints and attach to the face-plate by screws from the back. Place paper between the segments and the face-plate to prevent the ring from being glued to the latter. When one set or course of segments is complete, place the face-plate on the lathe and turn the face of segments true and straight across. Dress one side of the other four pieces and glue on the second course, placing this set of joints between the joints of the first course. Clamping one course to the other with hand screws, until the glue is dry and hard. The dogs or binders as shown in Fig. 168 must be used in drawing together

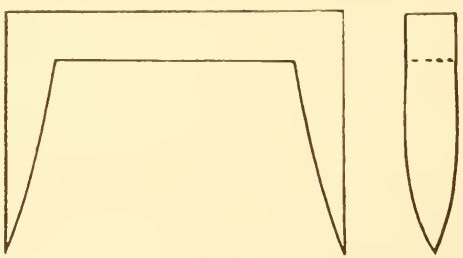


Fig. 168.

the end joints of segments and should be left in position until the glue is dry. When the glue is well set, remove the clamps and dogs and place in the lathe and proceed to turn the ring in the following manner:

With the square edge scraping tool remove the flat face of the outer course of segments until its thickness is 7-16 inch. Turn outside diameter to 6 inches and the inside to 4¼

inches. With the same tool remove the corners until the outside course of segments in section would form one-half of an octagon as shown in Fig. 169. Next remove the corners and

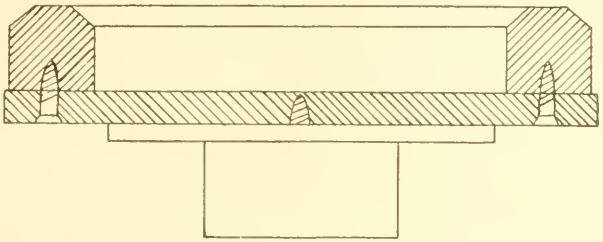


Fig. 169.

form a half circle of the section of the first course, when the work will appear as in Fig. 170. Remove the screws and the ring from the face-plate and with the

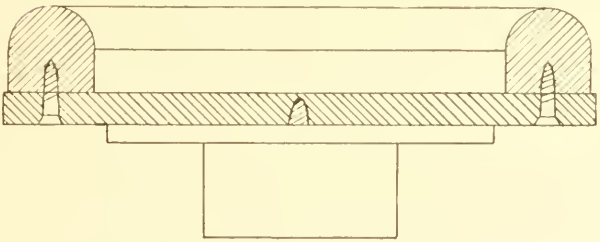


Fig. 170.

square edge scraping tool cut out the edge of disc until the center appears as in Fig. 171 and is of proper diameter

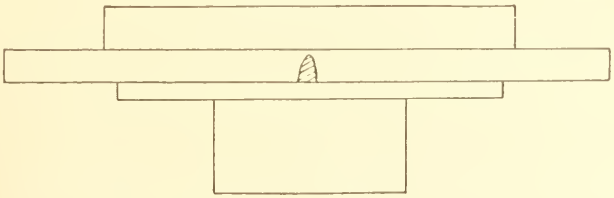


Fig. 171.

for the ring to fit tightly over. Place the turned side of ring next to face-plate and press firmly in position when the

piece will appear as in Fig. 172. With the ring in this position it may be finished to the proper dimensions with the square edge scraping tool. When sand-papered, varnished and pol-

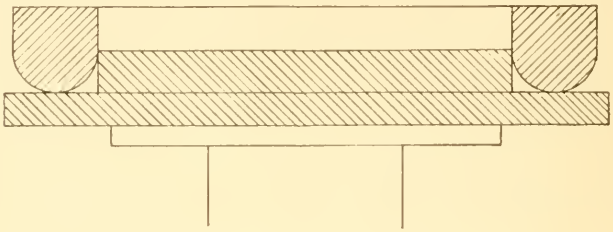


Fig. 172.

ished, the ring will be complete. Before removing the work from the face-plate, mark a line at the point marked A, in Fig. 173, with a sharp point of the compasses. This line is for the

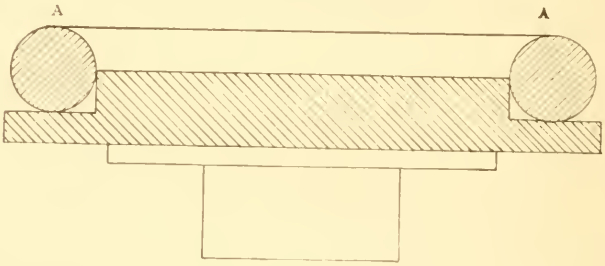


Fig. 173.

purpose of centering the hub, that is, locating its center on the arms after they are inserted. Remove the ring from the face-plate and it is ready for the arms. Dress out a piece 7-16 inch in thickness and 1½ inches wide and of proper length for the arms. Set the compasses to the radius of the circle marked on the ring and from the center of this piece mark lines on each end of the piece to correspond with the centering circle. Cut to this line and place the piece in position on ring, and mark at the edge of piece to outline the recess or pocket to be cut in ring to receive the arms. Cut out to the centering circle and to the lines marked when the piece was in position on the ring, cutting half way through the ring.

Place the piece in position in pockets cut, when it will appear as in Fig. 174. Next turn the hub to the dimensions given. Scribe a circle at the center on arms, the size of hub, and place

Fig. 174.

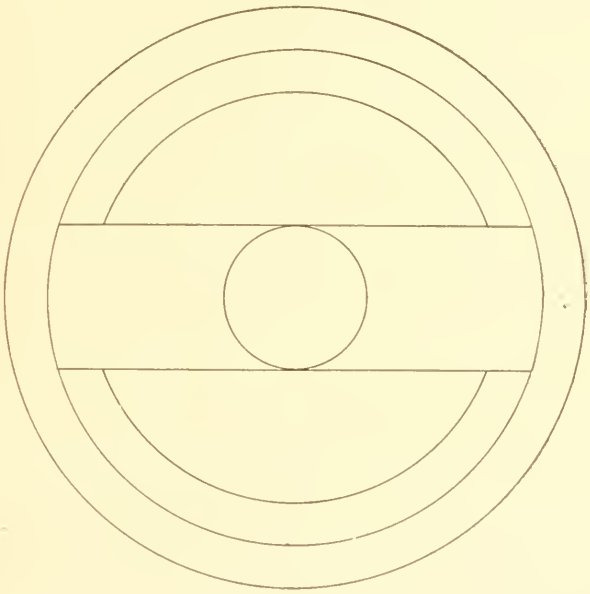


Fig. 175.

hub in its proper position. See Fig. 175. With the paring chisel and knife reduce the arms to an elliptical form, leaving fillets where the arms enter the ring. Sandpaper the arms, shellack and polish.

EXERCISE NO. 6.

Exercise No. 6 is a base for a small jack-screw and is shown in Fig. 176. This pattern may be made in one piece and cast in a plain mold. The position to be bottom upward

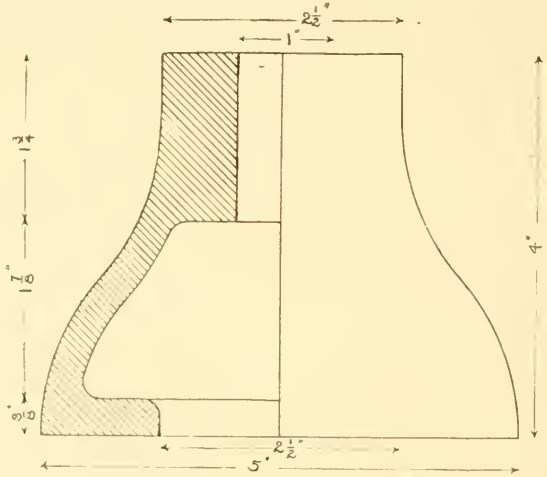


Fig. 176.

when cast. The material for the pattern should be two pieces each 5½ inches by 5½ inches by 2 inches. Dress one side of each piece and glue together the dressed surfaces. When the glue is dry dress one broad surface of the glued pieces. With the compasses set at 2⅝ inches scribe a circle 5¼ inches in diameter on the dressed surface. Saw to this circle on the band saw. Attach to the small face-plate with the center screw, and turn the concave surface with the round-nose scraping tool and the convex with the square edge tool. To get the curves correctly in this pattern and core box, the work should be tested by templets, which show the curves outside and inside of the casting to be made from the pattern. Otherwise, the proper thickness of the metal may not be obtained. When the curves are perfect on the outside surface, sandpaper and

polish. Remove from the lathe and turn prints for each end of the pattern to correspond with the size of the openings in

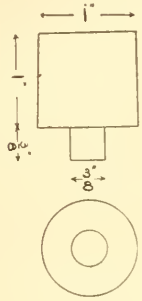


Fig. 177.

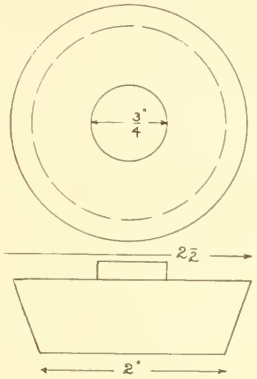


Fig. 178.

the ends of the casting. The small print on the top of pattern should be 1 inch in diameter and 1 inch in height and attached to the pattern as shown in Fig. 177.

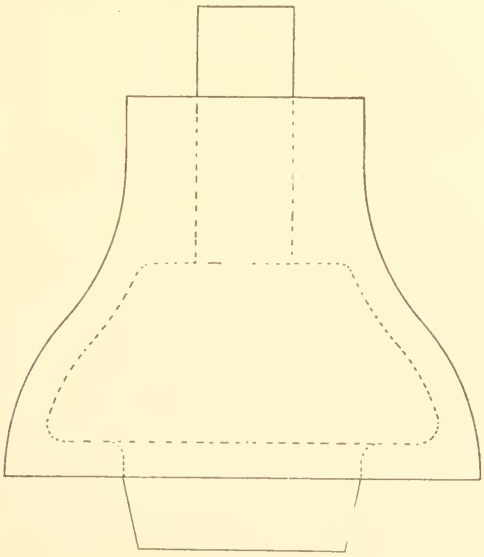


Fig. 179.

The hole in the pattern should be bored at the center. The larger print should be 2½ inches in diameter and ¾ inch in thickness, with a dowel at the center. The diameter at the top should be ½ inch less than at the base of print. See

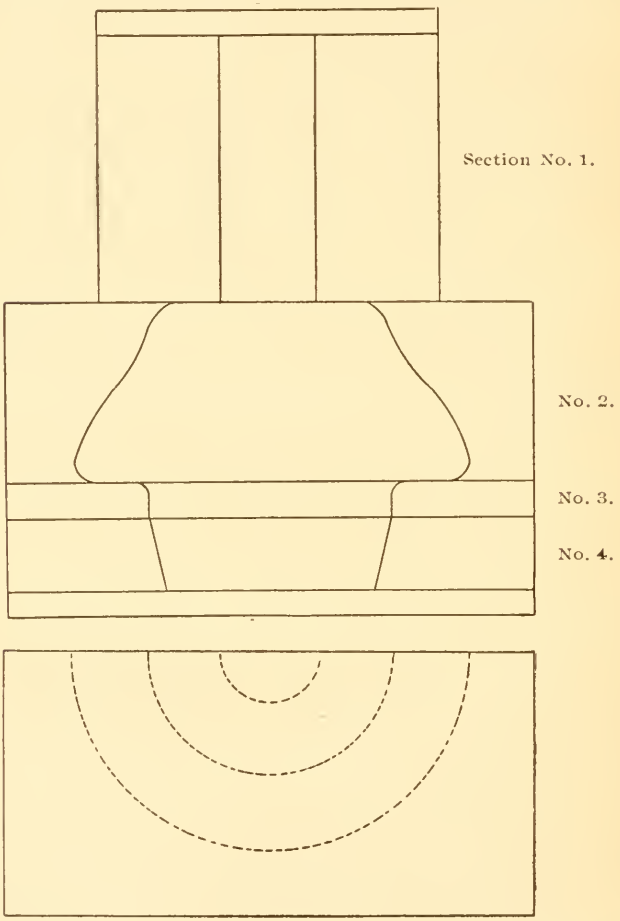


Fig. 180.

Fig. 178. These prints are to be varnished yellow. When the prints are on the pattern, the pattern will appear as in Fig. 179. The core to be formed in the box to be made is outlined

by the prints on the pattern and the dotted lines in Fig. 179. A core box to form one-half of the core will be sufficient. Construction of the box may be best accomplished by making it in sections as shown in Fig. 180. Section No. 1 may be done most advantageously by laying out the lines with the compasses and square and paring out with the gouge. No. 2. may be attached to the face-plate and turned out with the round-nose scraping tool, using the templet to test the curves. Nos. 3 and 4 may be done either on the face-plate or cut out with the gouge. When the pieces are all formed glue the parts together, sandpaper and varnish and the box is ready for the foundry. The core box will form a half-round core and two are needed to form the complete core.

EXERCISE NO. 7.

Exercise 7 is an elbow pipe coupling and is shown in Fig. 181. The size of the pipe this elbow is to accommodate is 1½ inches inside and 1 15-16 inches outside measurement, al-

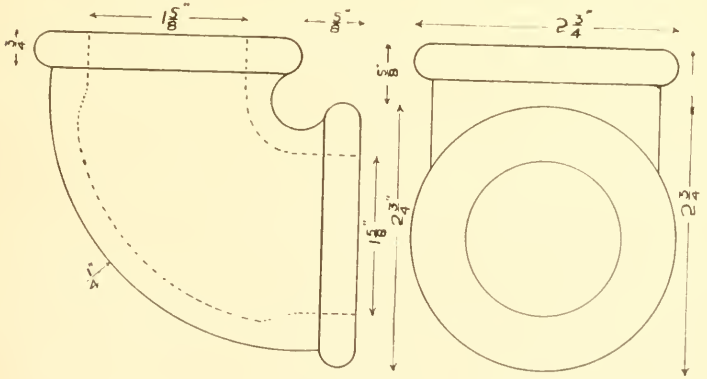


Fig. 181.

lowance to be made for thread cutting on the inside of elbow. To construct this pattern proceed in the following manner. Saw a piece 12 inches by 3 inches by 1½ inches. Plane one side true; saw the piece in two parts and place the dressed surfaces to-

gether and fasten at the ends with screws. The piece will appear as in Fig. 182. Bore holes and place 3/8 inch dowel

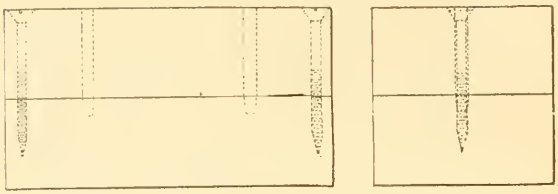


Fig. 182.

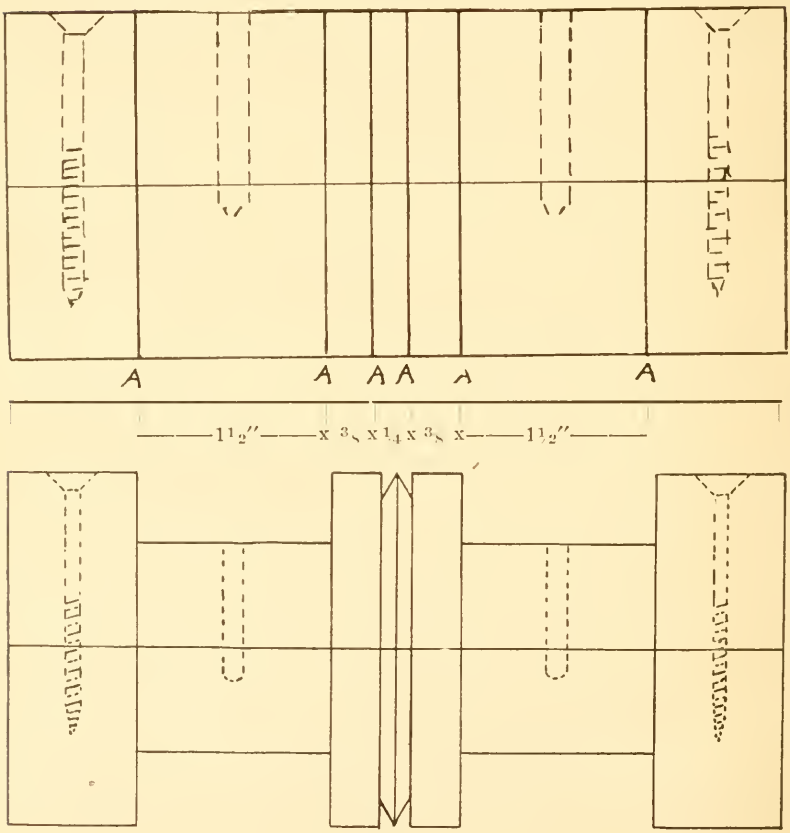


Fig. 183.

pins 2½ inches apart as shown by dotted lines in Fig. 182. Place the piece in the lathe and reduce to 2¾ inches diameter. With the compasses mark lines on the piece as shown at A,

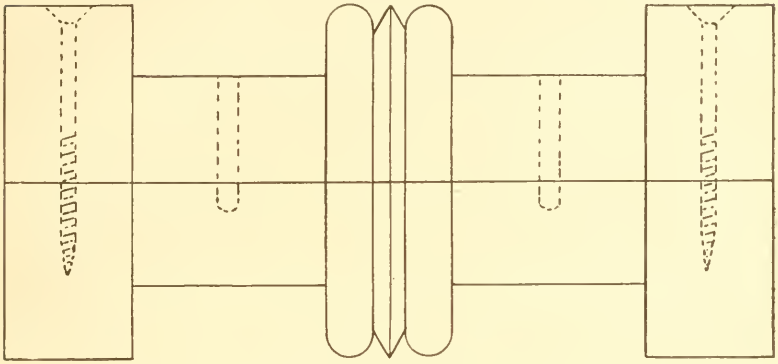
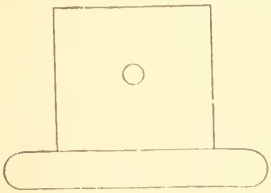


Fig. 184.

Fig. 183. With the small skew chisel cut away and reduce the diameter to 1½ inches between the lines which are 1½ inches apart. Sandpaper and varnish this portion yellow.



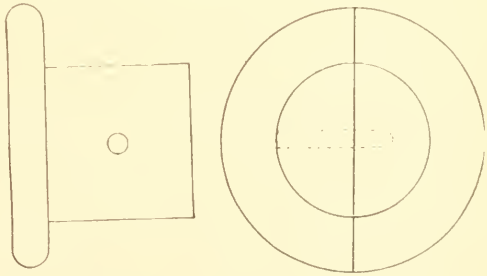


Fig. 185.

Next, form with the skew chisel the beads and varnish them

black. The piece will then appear as in Fig. 184. Cut off the ends at the core prints and cut pieces into two parts, when they will appear as in Fig. 185. Mark out with the compasses and saw on the band saw a disc 2 inches thick and 6 inches in diameter. Place this on the face-plate and turn to the shape shown in Fig. 186. Cut out of this two quadrants

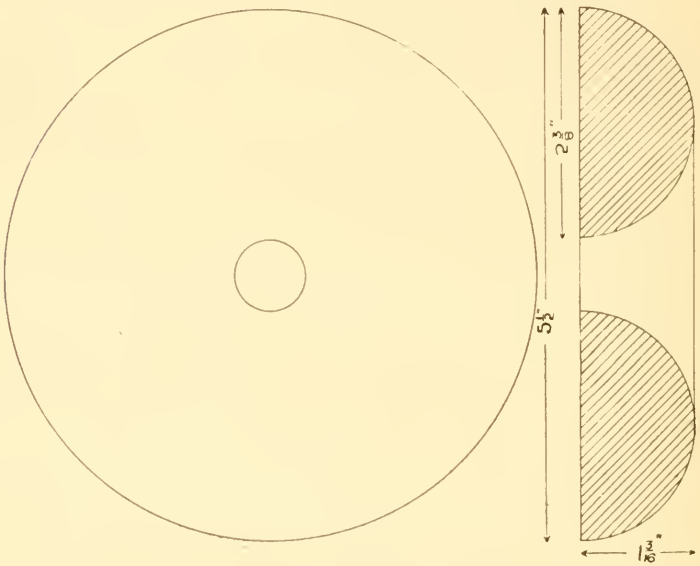


Fig. 186.

and glue to the pieces previously formed and the work will then appear as in Fig. 187. When the piece has been properly sandpapered and varnished it is complete. The core box for this pattern should be made in the following manner. Select a piece of material 1½ inches in thickness and 4 inches by 6 inches and lay out as shown in Fig. 188. When the laying out has been done as is shown in the sketch, cut off the ends of piece to the oblique lines marked A-A in Fig. 188. Square these ends to surface No. 1, the surface on which the lines are. With the compasses scribe a line on the ends

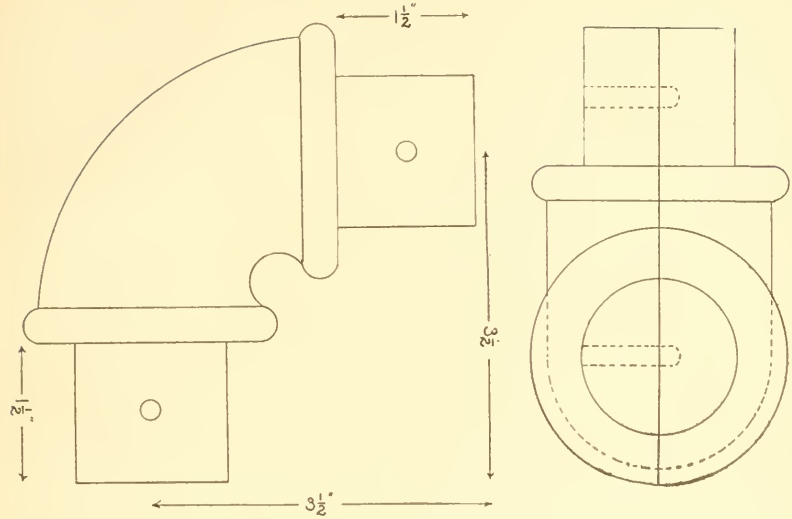


Fig. 187.

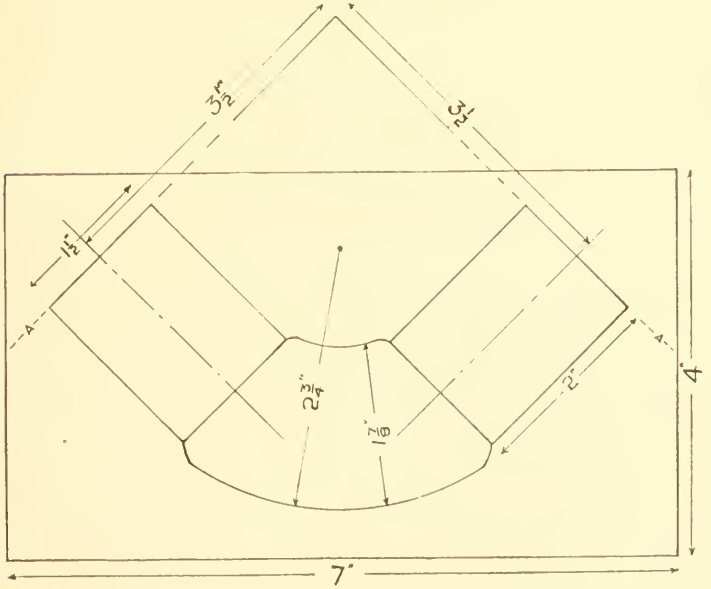


Fig. 188.

between the lines which are 1½ inches apart. With the paring gouge and carving tool or outside ground gouge, work out the lines to a depth equal to half the distance between the lines. The sectional view of the core box will then be a half circle. This half circle may be proven by the try square. Sandpaper the inside of box and when the ends have been put on, the inside and top of box should be varnished in the same manner as the pattern. This core box forms only one-half of the core. However, the core maker is able to form a whole core from a half core box, by pasting together.

EXERCISE NO. 8.

Exercise No. 8 is a pattern for a small pulley as shown in Fig. 189. This pattern should be made as follows: Saw on the band saw a disc ¾ inch in thickness and 6½ inches in

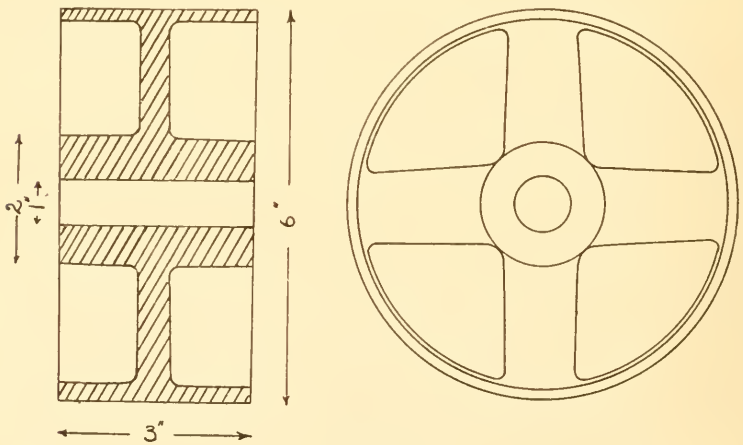


Fig. 189.

diameter. Place this on the face-plate of the lathe and turn up its face. Dress material for the arms of the pulley to ¼ inch in thickness and 2¼ inches in width and 3½ inches in

length. Eight pieces will be required to form the arms. Place four of them on the face-plate in the manner shown in Fig.

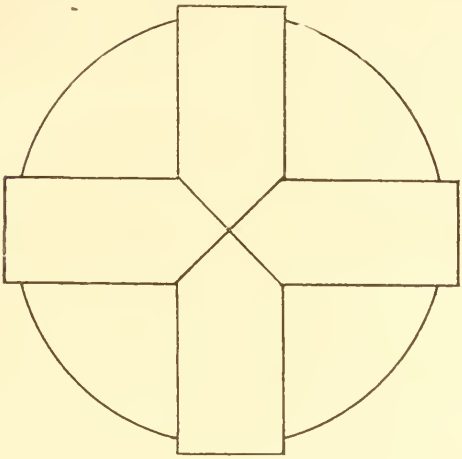


Fig. 190.

190 and attach to face-plate with nails near the edge of pieces. Glue the pieces together so as to form one piece. Place paper

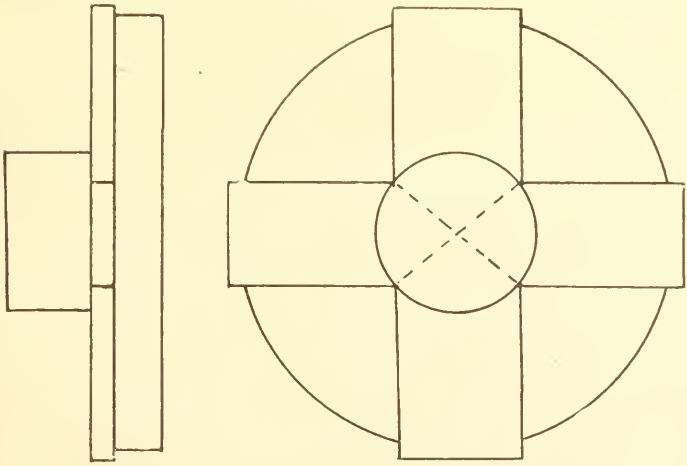


Fig. 191.

on face-plate before glueing, to prevent glueing to plate. Saw

out hubs to glue on at the center of arms. The pieces will appear as in Fig. 191. With the compasses, next lay out a pattern for the segments of the rim of the pulley as shown in Fig. 192. Place these pieces on the face-plate in the manner

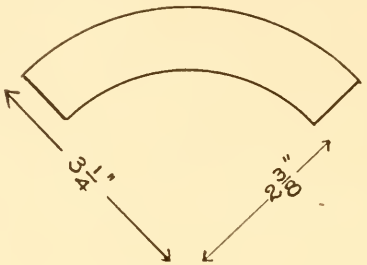


Fig. 192.

shown in Fig. 193. The segments must be fitted over the arms and ends joined on the arms. Glue ends together and to the

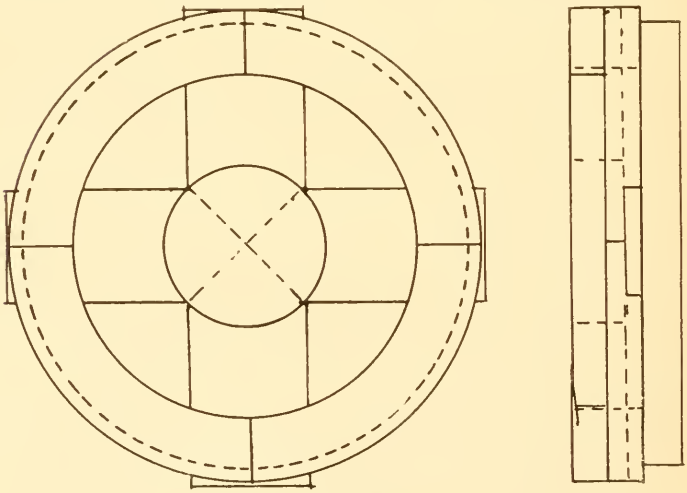


Fig. 193.

arms. Clamp together with a dog and small hand screw until dry. Place the piece on the lathe spindle and with the square edge scraping tool face off the rim until true, when it is ready for the next course or layer to be glued on. Dress one

side of the pieces to be glued on. Dress the ends smoothly and glue on first piece with its center directly over one of the joints in the first course. Clamp down firmly with two small hand screws. Fit ends of the next piece so as to rest evenly around the rim; glue and clamp the ends together with a dog, and clamp down piece with hand screws as before. Continue this course around until the circle is complete, and the piece will appear as shown in Fig. 194. When the glue is dry re-

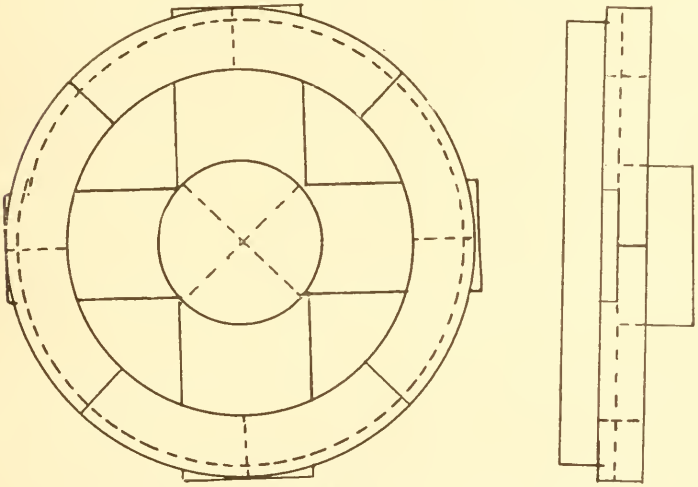


Fig. 194.

move the clamps. Place the piece on the lathe spindle and turn the rim and hub of this half of the pattern. The other half may be constructed in the same manner after the first has been turned and removed from the face-plate. The arms of the pulley may next be marked out on one-half of the pattern and cut to the line with the chisel and gouge, after which the two must be doweled together with pins through two of the pulley arms and the second half of pattern dressed to the same form as the first. Then round the arms to an elliptical form as shown in Fig. 189. Sandpaper and varnish the pattern and it will be ready to receive the core prints. The core prints,

1 inch in diameter and 1 inch in height, are to be doweled on at the center of the hub on outside end of each half of the hub. They should be exactly at the center where the opening for the shaft is to be in the hub of the pulley. When the core prints are in place the pattern is complete. A sectional view of the hub and core prints is shown in Fig. 195. The dotted lines

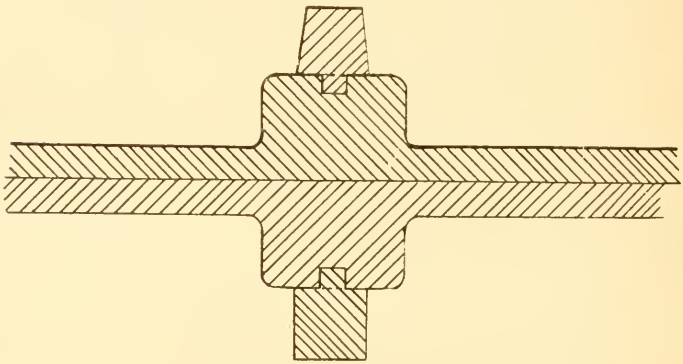


Fig. 195.

through the hub show the size of the opening to be cored through the hub. The core box to form the core must next be constructed. The core box must be made to mould a core one inch in diameter and of a length to correspond with the length of the hub, with the height of core prints added. This would be: hub 3 inches and the height of prints each one inch, making the total length of core box 5 inches. The core box should be made by doweling together two pieces each 4 inches in length, laying out the inside of core box on the ends and gauging lines on the inside surfaces. Take the two pieces apart and work out insides to the lines with the ½ inch paring gouge and afterward smooth with sand paper on a mandrel to one inch in diameter. Next dress a piece one inch in thickness and 6 inches long and 1½ inches in width. Cut the piece into two parts and place the dressed edges together. Lay out the shape of the tapered core print, and work out with the gouge and

sandpaper inside surfaces. Fasten these pieces to one end of core box with nails and glue. Sand paper the ends and varnish

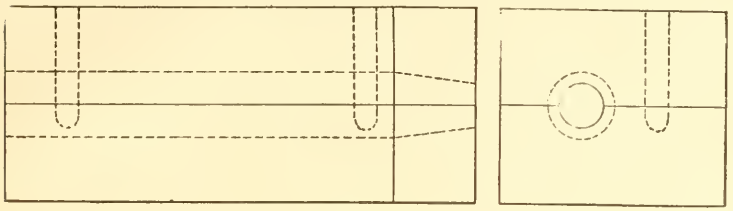


Fig. 196.

and finish inside and ends. The core box is now complete and will appear as shown in Fig. 196.

EXERCISE NO. 9.

Exercise No. 9 is a pattern for a small sheave or pulley to carry a rope or cable and is shown in Fig. 197. This pattern must be made in two parts, the same as the one in Exer-

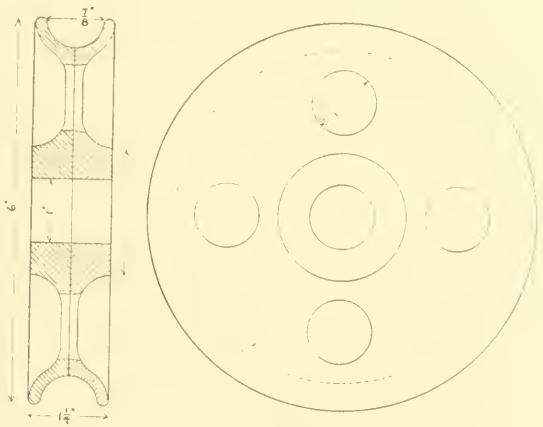


Fig. 197.

cise No. 8. However, it must be moulded in a different manner. The pattern must be formed on the lathe. First saw out

on the band saw two disks each 6¼ inches in diameter and ¾ inch in thickness. With one side dressed smooth, place each on the lathe and turn to the prescribed form with the round-nose and square edge scraping tools. Smooth with sand paper and finish with varnish. Remove from the lathe and dowel the two pieces together. Lay out the four one inch openings to be cut through the web of the sheave and work out separately with the auger bit and gouge. Sandpaper with the paper on a tapered mandrel to give the openings a draft toward the parting line of the pattern. Varnish and finish inside of openings. Place core prints on the hub in the same manner as in the preceding exercise and the pattern is finished. The core box is to be made in the same manner as in Exercise No. 8, the length over all to be 3¼ inches. The grain or fiber of the wood should run across and not lengthwise of the core box. When the core box has been varnished and finished on the inside and ends the work is complete.

EXERCISE NO. 10.

Exercise No. 10, shown in Fig. 198, is a screw for a worm gear. This pattern is a rather difficult one for a student to attempt to make, but with care and perseverance the work

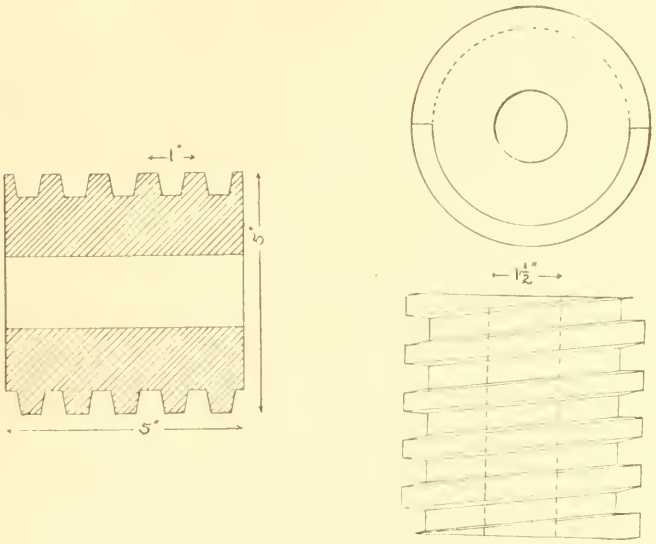


Fig. 198.

may be done and when completed successfully the student will be capable of doing almost any job of pattern making that may be assigned him. Begin the pattern by dressing on one side a piece which is 2¾ inches by 5¼ inches by 20 inches. Cut the piece into two parts and place together the planed surfaces. Fasten at the ends with screws; place dowel pins in the piece a distance of 6 inches apart; place in the lathe and turn to a cylinder 5 inches in diameter. When this has been done the piece will appear as shown in Fig. 199. Lay out and turn to the dimensions indicated by the dotted lines. Varnish this cylinder yellow for the reason that the

varnish hardens the surface and the fine lines to be marked may be made and worked more accurately. Saw off at the ends of core prints and dress the ends. Part the pattern and

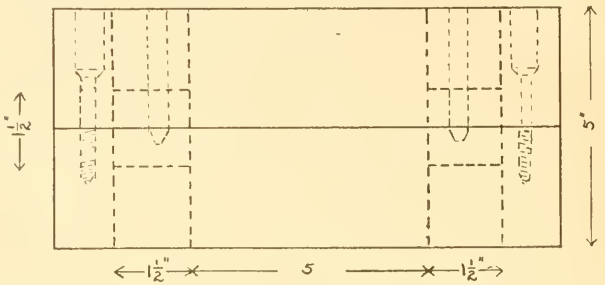


Fig. 199.

lay out the screw in sections as shown in Fig. 200. The laying out of the lines may be done more easily by first making a templet to the form of a section of the tooth or thread and

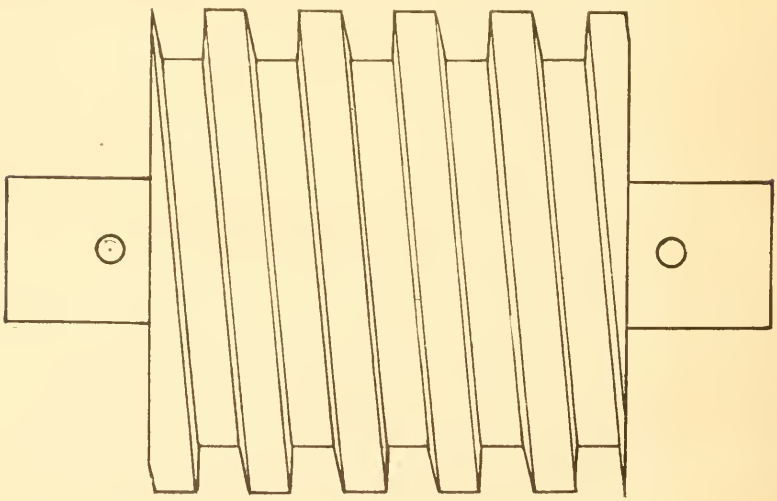


Fig. 200

marking to the form of the templet on the inside surfaces. First it is necessary to square lines across to give the position

of thread on each edge of surface. Place the templet in position between the lines drawn, and scribe around it. When the lines have been formed on the inside surfaces, one to correspond with the other, a flexible rule may be sprung around the outer surfaces to guide the marker in laying out the lines on the convex surface of each half of the pattern. An adjustable blade back saw is a very convenient tool for cutting to the proper depth between the threads. This saw being adjustable may be set to saw to the depth desired and cannot cut deeper. By following around the convex surface near the line of the thread and cutting to the required depth, the portion to be cut away may be easily removed with a narrow paring chisel. A templet of the form required between the threads must be made and the portion not yet cut away must be removed with the paring chisel, paring toward the center line of the pattern, testing the correctness of the work with the templet. When the cutting away is finished, sandpaper the pared surfaces and varnish the body of the pattern black leaving the core prints yellow. With the varnish properly smoothed, the pattern is finished.

The core required for this pattern is 1½ inches in diameter and 8 inches in length. This core may be more conveniently made by a half core box as shown in Fig. 201. After

Fig. 201.

the core maker forms the cores in the half box the halves are joined together to form a whole.

The exercises given in the foregoing pages are deemed sufficient, if properly performed, to train the student in this line of work and to enable him to take part in the construction of the various parts of any machine which may be under construction in the pattern shop. It is the usual policy to allow

each class in shop practice to construct the patterns, mould, cast and erect in the machine shop some machine. When this plan is followed it is impossible to outline a course beyond this point. It is, however, deemed sufficient, and in case the student shows aptness in the work he should be allowed to discontinue the regular course and begin on machine construction. When this work is begun, personal instruction will be necessary.

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